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PHYSIOLOGIC CONSIDERATIONS OF ILEUS*

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NORMALLY the function of the gastrointestinal tract is that of digestion and assimilation, which is accomplished through secretion, peristalsis, and absorption. Although the gastrointestinal tract is supplied by an intrinsic nerve mechanism, the plexuses of Auerbach and Meisner, the secretion and motility are also regulated by extrinsic nerves, the sympathetics and the parasympathetics. Bayliss and Starling[2] and Macleod[29] have shown that although peristalsis and secretion will continue in the experimental animal following the removal of all the extrinsic nerves, irritation, stimulation, or inhibition of these nerves does produce changes in intestinal activity, both motor and secretory. Clairmont and Ranzi[8] believe from their experimental observations that absorption from the gut in intestinal obstruction is temporarily increased, but later is markedly decreased. Enderlen and Hotz,[14] Braun and Boruttau,[4] Esau,[15] and Heusser and Schär[26] state that absorption from the intestine is decreased from the beginning of the obstruction. Müller[36] showed that in ileus there is an increased secretion into the gut lumen. Seulberger, Brandes, and Roth,[43] in an extensive experimental investigation, demonstrated that in ileus there was definite decreased absorption from the obstructed gut. This they believe is due to the hypertonicity of the contents of the bowel in ileus and that as the distention increases the vital selective absorbability of the intestinal mucosa is lost and it acts as a diffusion membrane. Matthaes[30] showed both clinically and experimentally that absorption from the stomach was much less in an animal with ileus than in the normal animal. Kin[27] demonstrated that in "high" intestinal obstruction the gastric secretion was markedly increased, and that it was proportionately greater in animals with the obstruction below the ampulla of Vater than in those with the obstruction above this site. Concomitant with the increased gastric secretion was an increase in chloride secretion. In ileus there is increased secretion into the gastrointestinal tract, diminished absorption from the gut, and lack of transportation of the intestinal secretions from the upper secretory portion to the lower absorptive areas. This results in accumulation of gas and fluid in the loops of bowel which is of great importance to the roentgenologist because of his ability to demonstrate the presence of this accumulation by flat plates of the abdomen. There is no graphic method as reliable as the visualization of multiple fluid levels in cases of ileus whether they are produced by mechanical obstruction or associated with adynamic ileus. In an

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extensive experimental investigation, I[39] showed that ileus could be demonstrated roentgenologically as early as one hour after a strangulated obstruction (Fig. 1), and as early as three hours after simple obstruction (Fig. 2). The earliest roentgen evidence of obstruction was found to be gas accumulation and not gas and fluid. absence of interference to the blood supply of the intestine produces, aside from obstipation, relatively few symptoms and signs in clinical cases. Also there is a considerable difference in the clinical manifestations and the prognosis in cases with relatively "high" and those with relatively "low" mechanical obstructions. Possibly

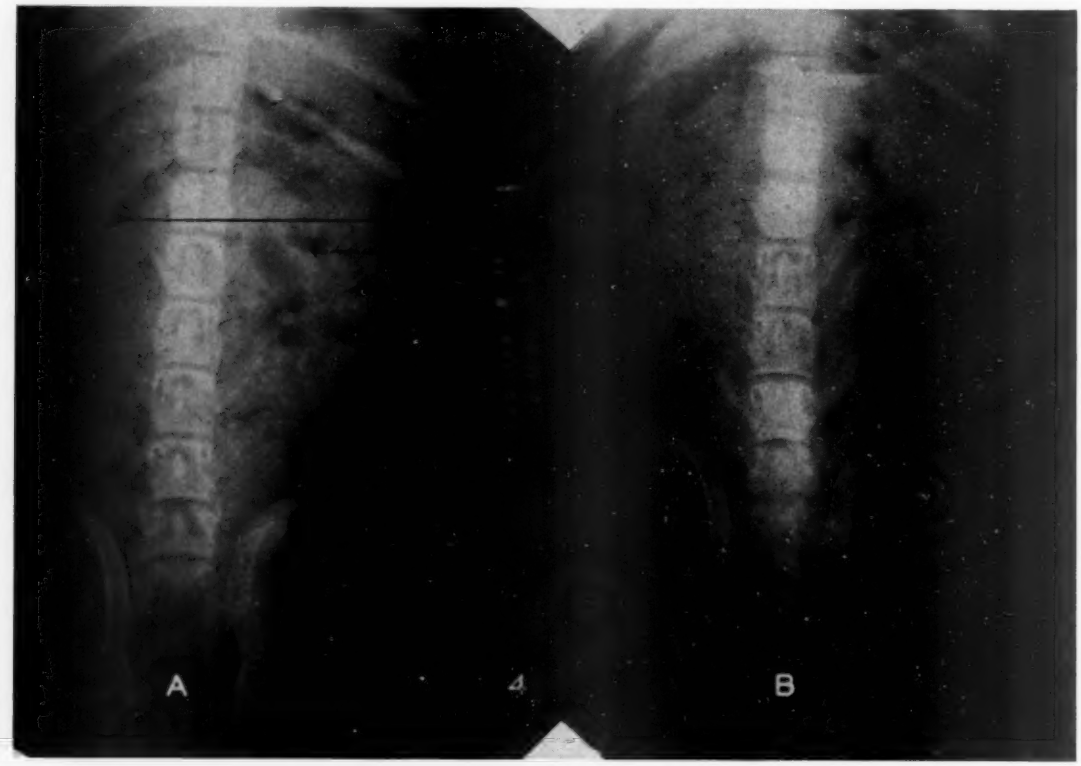

Fig. 1. Roentgenogram of animal with strangulated obstruction produced one hour previously. As shown in A and designated by the arrows, there are a number of fluid levels. A was taken in the upright position in such a way that the roentgen rays paralleled the surface of the fluid. B was taken in the supine position so that the roentgen rays were at right angles to the surface of the fluid.

Morin and Vial[32] showed that distention of the duodenum or jejunum produced reflex inhibitions of the gastric and the small and large intestinal motility and that these inhibitory impulses were conducted over the splanchnic nerves.

In a consideration of ileus, it is essential to differentiate between those cases in which there is only a mechanical obstruction to the fecal stream and those in which there is an interference with the blood supply to the gut. As is well known, mere obstruction of the intestinal tract in the the separate consideration of the level of the obstruction and the vascular supply is an artificial one, because the two may be quite dependent upon one another. Murphy and Brooks,[37] Brooks, Schumacher, and Wattenberg,[5] Dragstedt et al.,[10] and Gatch, Trusler and Ayers[16] demonstrated experimentally that strangulation favors the absorption of toxic material from the intestinal lumen and that in experimental closed loop obstructions, the shorter the loop the more rapid is the intoxication. Owings et al.[40] showed that following in-

testinal obstruction the intra-intestinal pressure was increased, the pressure varying with the amount of peristaltic activity which was greatest in the upper portion of the intestinal tract. Morton[33] found that there was considerable difference between the pressures within a loop of duodenum and one of the lower ileum. Whereas the normal intra-intestinal pressure varies from 2 to 4 cm. of water, he found that after obstruction is present for twenty-four hours the pressures within the duodenum and the ileum increased from 28 to 36 and from 4.5 to 5 cm. of water, respectively. This increase in the pressure in the upper intestinal tract over that of the lower results from the marked secretion from the duodenal mucosa as well as the presence of the biliary and pancreatic secretions, whereas in the lower part of the intestinal tract the mucosa is largely absorptive. Morton[33] found that the duodenum secreted from five to ten times as much fluid as the ileum in a given period of time. It is obvious from these observations that, everything else being equal, an obstruction high in the intestinal tract will produce a greater distention of the intestine than a similar obstruction in the absorptive portion of the ileum and the colon. Morton[33] is of the opinion that obstructions low in the intestinal tract are similar to those with a long closed loop, whereas a similar obstruction located at a higher level is comparable to a short closed loop with its greater mortality.

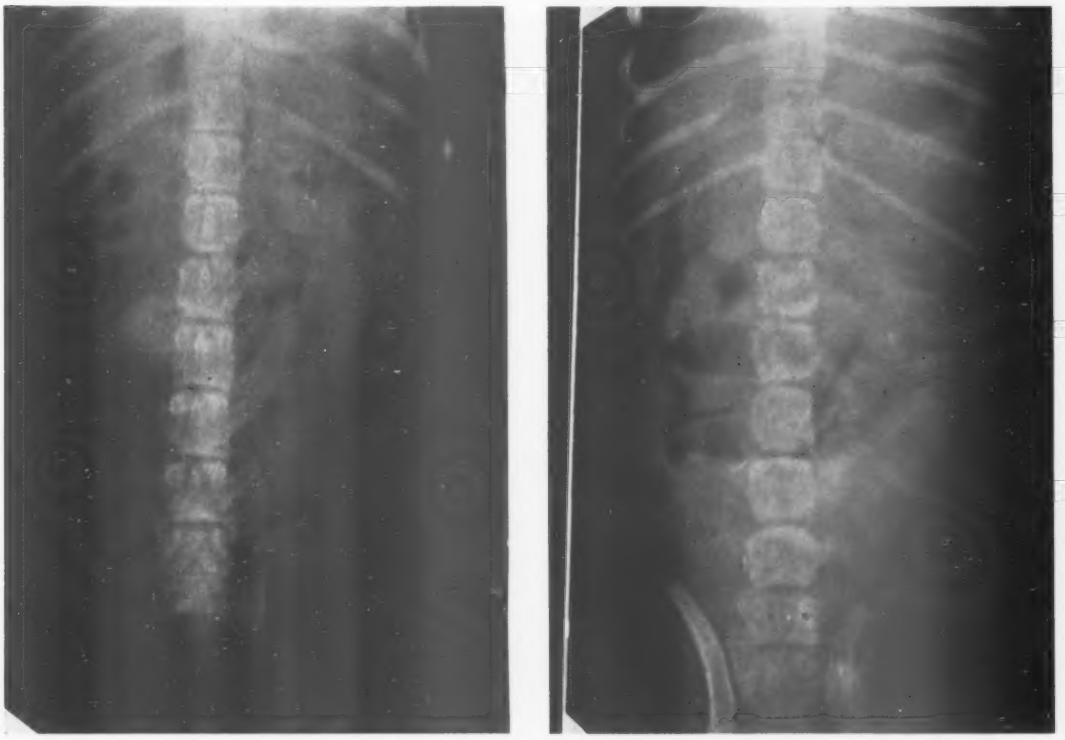

Fig. 2. Roentgenogram of animal with three hour simple obstruction. There is definite gaseous distention shown in both roentgenograms, one of which was taken in the upright position and the other in the supine position. Some fluid levels are demonstrable in the roentgenogram taken in the upright position.

Dragstedt, Lang, and Millet[11] have shown that there is considerable variation in the intramural blood supply in the various parts of the intestine, and as a result of this anatomical variation, pressures within the gut exert varying influences on

the blood supply of the intestinal wall. They found that the flow in the veins of the walls of the intestine ceased when the intra-intestinal pressures within the duodenum, the jejunum, the ileum, and the colon attained heights of 35 to 45, 55 to 65,

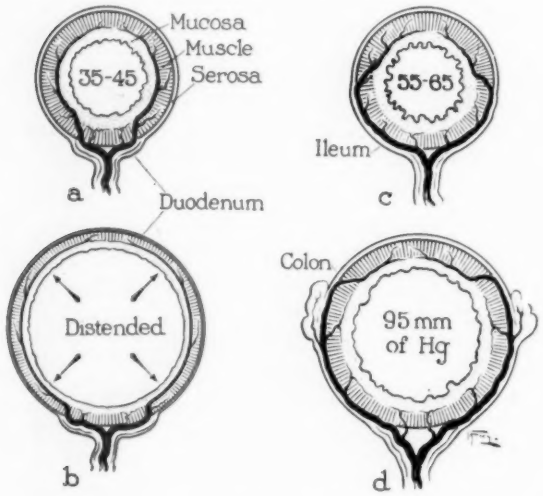

Fig. 3. (After Dragstedt, Lang, and Millet.)[11] Diagrammatic drawing showing the effect of distention upon intramural blood supply. *a* shows the relationship of the vessels of the bowel to the wall of the bowel as it exists in the case of the duodenum. The vessels enter the bowel at the mesenteric attachment, course around subserously until they reach the positions of five and seven o'clock and pierce the muscularis to course around within the muscularis for the rest of the distance to the antemesenteric border. *b* shows relationship of the vessels in the ileum. The vessels course around subserously until about midway around the circumference and then pierce the muscularis. In *c* the vessels course around subserously to the antemesenteric surface at approximately one and eleven o'clock and pierce the muscularis at these points. *d* shows the effect of distention of the duodenum on the blood supply to this portion of the bowel, resulting in an intramural strangulation.

and 95 mm. of mercury, respectively. This, they believe, is due to the variation in the length of the intramural blood vessels. They found that if a cross section of the bowel were represented by the face of a clock with the mesenteric attachment at six o'clock, the vasa recta pierce the muscularis in the case of the duodenum at approximately five and seven o'clock, in the case of the jejunum and the ileum at three and nine o'clock, and in the case of the colon at two and ten o'clock. In the duodenum any increase in intra-intestinal tension exerts considerable pressure on the vessels which lie between the mucosa and the relatively inelastic muscularis. In the colon, however, in which the greater portion of the vessel lies outside the muscularis, an increase in the intra-intestinal pressure exerts relatively little effect on the blood supply (Fig. 3). Because the secretion is much more marked in the upper intestinal tract than in the lower as the result of the pouring into it of the duodenal, the pancreatic, and hepatic secretions and also because of the peculiar anatomic arrangement of the duodenal and the jejunal vessels, it is obvious that an obstruction high in the intestinal tract is likely to produce interference with the blood supply and strangulation within the wall of the bowel. This is probably the reason why toxemia in "high" intestinal obstruction is much more severe than in a similar obstruction lower down. Morton and Sullivan[31] compared equal sized closed loops of the duodenum and the ileum and found considerable differences as regards the amount of secretion and intestinal distention. They found that there is an average secretion into the duodenum of 49 c.c. as compared with 0.9 c.c. for the ileum. Most of the animals with the duodenal closed loops died from rupture of the duodenum after the end of forty-eight hours. The intra-intestinal pressures were measured and it was found that the pressures within the duodenal segments markedly increased until they were from four to seven times as great as those in the ileum. Burget et al.[6] demonstrated that symptoms in experimental animals with closed loops were dependent upon the distention within the loops. They determined the intra-enteric pressures of subcutaneous loops and found that the animals exhibited no toxic symptoms as long as the intra-intestinal pressures were low. However, as soon as a loop became distended, the ani-

mal presented signs of toxicity; i.e., did not appear lively and refused food. On the other hand, when the contents of the loop were aspirated and the intra-intestinal pressure relieved, these symptoms quickly disappeared. If the distention of the loops was allowed to continue, vomiting and apparent depression occurred and a longer time was required for the animal to recover following relief of the pressure within the closed loop. Raine and Perry[41] demonstrated experimentally the importance of intra-intestinal pressure in producing symptoms in obstruction. In experimentally produced obstruction of the ileum in rabbits following the administration of rather large amounts of water at frequent intervals, there occurred no evident increase in intra-intestinal pressure, probably because of absorption of the fluid. If, however, liquid albolene which was not absorbed was administered, the animal died relatively quickly and showed the same blood changes as those shown by animals with "high" jejunal obstruction.

In "high" intestinal obstruction in the absence of interference with the blood supply of the intestine, dehydration and a hypochloremia occur as a result of loss of fluids and hydrochloric acid in the vomitus. Hartwell and Houget,[25] in 1912, demonstrated that animals with obstruction could be kept alive for long periods of time by the administration of large amounts of normal saline solution and because of this believed that the symptoms in acute intestinal obstruction were due to dehydration. Subsequently, Draper[12] made the same observation. Haden and Orr[19-23] further showed that typical blood changes occur in intestinal obstruction which consist of decrease in the blood chlorides and a rise in the carbon dioxide combining power (alkalosis). The hypochloremia resulted, they believed, because of the combination of the chloride fraction with toxins elaborated in the gut. In all probability, however, the decrease in plasma chlorides is the result of the loss of the chlorides in the vomitus. There are many who believe that the toxic manifestations associated with intestinal obstruction are not due to the absorption of a toxin elaborated in the bowel but are the result of the blood changes associated with the obstruction. Brandberg[3] believes to have proved that the cause of death in "high" intestinal obstruction is loss of electrolytes and fluids. Similarly, Armour et al.[1] maintain that death in "high" intestinal obstruction is not due to toxemia but to chemical changes resulting from loss of chlorides and water. Morton and Pearse[34] compared the effects produced experimentally in rabbits and in dogs with "high" intestinal obstruction and with "high" intestinal fistulae. The average time of survival in the rabbits with "high" intestinal obstruction was thirty hours, whereas that in animals with "high" intestinal fistulae was thirty-three hours. In dogs, the average time of survival in the presence of "high" intestinal obstruction was five and four-fifths days, whereas in those with "high" intestinal fistulae it was five and one-half days. The blood chloride and non-protein nitrogen values were similar in both conditions. From these observations Morton and Pearse[34] believe that the symptoms in "high" intestinal obstruction and in "high" intestinal fistula are not due to toxemia, but to a deficiency of the essential secretions lost from the upper intestinal tract. Haden and Orr[19-23] also believe that hypochloremia is a factor.

Häbler,[24] in experiments on animals with a Pavlov intestinal fistula of the upper intestinal tract with obstruction, found that if the contents from the upper intestinal fistula were neutralized by the addition of alkalies and incubated for four days and returned through the fistula into the intestinal tract, the signs and symptoms of intestinal obstruction developed and the animals eventually died. There was no decrease in the blood chlorides, because chlorides were administered to the animals. Häbler believes from these observations that death in intestinal obstruction is not due to a chloride deficiency and that the

administration of chlorides alone is not enough to relieve the toxemia. This contention of Häbler's is borne out by clinical observations, because, although the importance of hypochloremia and dehydration has been stressed since the investigations of Haden and Orr, the mortality rate from intestinal obstruction has been little changed; and were the symptoms and death due to the blood changes, relatively few patients with intestinal obstruction, either the mechanical or the adynamic varieties, should die, because it is relatively easy to replace the lacking blood constituents.

How can one, therefore, explain the symptoms and death in those patients with normal blood chemistry and with no evidence of dehydration, particularly after the administration of large amounts of chlorides? Unquestionably, death in intestinal obstruction is the result of the absorption of toxins which probably occurs only when there is an interference with the blood supply to the bowel; viz., strangulation. Numerous attempts have been made to demonstrate toxic substances in the blood stream draining the involved segment. This has been difficult, however, because, although there may be sufficient absorption from obstructed strangulated intestine to cause death in the affected animal, it is impossible to obtain all the blood draining from that area and the relatively slight effect exerted on an otherwise normal animal is not sufficient to cause death. Sugito[46] demonstrated that blood obtained from the superior mesenteric veins in animals with ileus was much more toxic than that obtained from the peripheral circulation. Scholefield[42] found that mesenteric blood from a strangulated loop in a dog produced toxic manifestations when injected into mice. Carlson, Lynch, and Wangensteen[7] performed similar experiments but obtained less marked results in that the blood removed from the portal veins of animals with ileus caused only temporary symptoms when injected into other animals. Nemiloff and Perumova,[38] on the other hand, were unable to find any evidence of toxic substances in the portal blood or the hemorrhagic serous peritoneal exudate in dogs with intestinal obstruction. The failure to obtain any toxic manifestations when these substances were injected intravenously into normal animals may be due to the fact that relatively small amounts were used, 25 to 55 c.c. and 10 c.c., respectively. Relatively recently Knight and Slome,[28] in an excellent piece of experimental work, definitely showed that unless there is interference with the blood supply to a loop of bowel, there are few or no symptoms. They found that whereas simple obstruction of the midportion of the small intestine resulted in a survival time of approximately 240 hours, a closed loop without any interference to the blood supply resulted in a survival time of 163 hours. In a closed loop in which there was a total anemia, the survival time was forty-eight hours, whereas in a closed loop with interference to the venous return, the survival time was nineteen hours. They also showed that there was no relationship between the fluid loss and the survival period. Sweet[47] believes that as the result of intestinal obstruction there occur degenerative changes in the adrenal which in turn cause disturbances in the water metabolism and shock and that these changes are responsible for the persistence of symptoms and death in patients after relief of the obstruction.

The exact nature and origin of the toxin in ileus associated with interference to the blood supply is not known. A number of theories have been advocated to account for the production of the toxin, but it is likely that it is similar to a histamine-like product. Recently Moon and Morgan[31] have shown that there is a great deal of similarity in the post-mortem findings in intestinal obstruction and shock. They found that an extract of mucosa from obstructed intestine produced a marked fall in blood pressure and death; i.e., a picture of shock, similar to that produced by the

injection of histamine. They do not attempt to state whether it is due to histamine or products of protein cleavage, produced by autolysis. At post mortem the animals showed diffuse congestion of the lungs, the intestinal mucosa, the liver, the kidneys, and the bronchial mucosa. The adrenal glands were slightly congested. Knight and Slome[28] showed by cross circulation experiments that the fall in blood pressure is not the result of loss of blood. They selected two animals of approximately equal weights. One was prepared for superior mesenteric strangulation. The other animal's carotid artery was connected by means of a Payr cannula to the superior mesenteric artery supplying the segment to be strangulated. The superior mesenteric veins were then tied, and the clip removed from the carotid. The animal supplying the blood to the strangulated segment had little change in blood pressure, whereas the animal with the strangulated segment, although it had lost no blood, had a marked fall in blood pressure showing the absorption of some substance which produced a fall in blood pressure which could not be accounted for by loss of blood. Sweet[47] differentiates between the shock associated with intestinal obstruction or pancreatitis and that following massive hemorrhage in that in the former the mind is alert and active, whereas in the latter there is apathy and fainting. He believes that a histamine-like substance is formed in the obstructed bowel which produces adrenal insufficiency which in turn causes a disturbed water balance. Swingle and his associates[48] have shown that the regulation and maintenance of water balance in the vascular system is the function of the adrenal cortical hormone. Little is known concerning the character of the toxin. Murphy and Brooks,[37] and Whipple et al.[50,51] believe that it is a proteose. On the other hand, Gley and Le Bas,[18] and Ellis[13] are of the opinion that it is not a proteose. Gatch et al.,[16,17] and Dale and Laidlaw[9] believe that it is a histamine-like substance.

Absorption of toxic substances from an involved loop can occur either through the blood or lymphatic streams. Sugito[46] isolated a toxin from the blood of animals dying with acute ileus and demonstrated that the blood obtained from the superior mesenteric veins was much more toxic than that obtained from the peripheral circulation. Sperling and Wangensteen[45] found that in simple obstruction transperitoneal absorption can occur, but only when there is devitalization of the bowel as a result of distention, and that absorption from the bowel occurs more readily during obstruction than from normal bowel. These same authors[44] found that in the presence of obstruction and increased intra-enteric pressure there is increased lymphatic absorption of bacteria into the regional lymph nodes. Knight and Slome[28] determined the absorption of the toxic factor from the peritoneum by encasing their closed loop in rubber bags. It was found that if a non-viable loop and its contents were transferred to the peritoneal cavity of another animal and the abdominal walls of both together that the normal animal died within three and a half hours, whereas the strangulated animal died shortly afterward. These same observers showed that the blood obtained from the mesenteric veins of animals with obstruction when injected into the veins of normal animals produced a definite fall in blood pressure and that the greatest effect was seen in those cases in which the loop was not viable.

SUMMARY AND CONCLUSIONS

As the result of extensive physiologic and biochemical investigations, it is evident that in ileus there is considerable disturbance in the normal function of the gastrointestinal tract.

Whereas the normal function of the gut consists of peristalsis, secretion, and absorption, these activities are so altered in ileus that life of the individual is endangered.

Mechanical obstruction to the intestine

causes increased peristaltic activity which is expressed clinically by colicky or cramp-like pains in the abdomen and increased peristaltic sounds.

Adynamic ileus is the result of peritoneal or splanchnic irritation which can be mechanical, chemical, thermal, or bacterial. In both types of ileus, mechanical obstruction and the adynamic variety, there occurs increased gastrointestinal secretion, decreased absorption, and a failure of transportation of the gastric and upper intestinal secretions into the lower bowel, either because of the mechanical blocking or the absence of peristaltic movement. Concomitant with and dependent upon the increased secretion, diminished absorption, and retention are stasis of the secretions and dilatation of the stomach and upper intestine, which, if unrelieved, cause nausea and vomiting.

The secretion of large quantities of fluid and electrolytes from the stomach, duodenum, pancreas, and liver without subsequent absorption of these substances from the normal absorptive areas of the intestinal tract, the ileum and colon, results in the loss of fluids (dehydration) and electrolytes, particularly chlorides (hypochloremia). Although the fluid may remain in the stomach, it is lost to the body, as under such conditions it remains stagnant in the stomach and duodenum. It is far better for the patient that the stomach and the intestine be emptied of this material, because distention causes further secretion. It is for this reason that an indwelling duodenal catheter and active suction, as suggested by Wangensteen,[49] are used.

In addition to dehydration, hypochloremia, and alkalosis, symptoms can be caused by absorption of toxins from the involved bowel whenever there is interference with the blood supply to the gut. This strangulation may be extramural; i.e., in the mesentery, or intramural; i.e., within the wall of the bowel. The latter is likely to occur in "high" intestinal obstructions in which there is inadequate decompression of the stomach and intestine because of the peculiar anatomic arrangement of the blood vessels of the duodenum and upper jejunum which makes them particularly vulnerable to pressure (Fig. 3).

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DISCUSSION

Dr. L. R. Sante, St. Louis, Mo. We, as roentgenologists, must be fully aware of the significance of the physiological processes giving rise to gastrointestinal phenomena in order to interpret our findings properly. The literature is replete with investigative work of this type on the gastrointestinal tract; in fact, the mass of material is so great that papers such as the one just given are absolutely essential for its proper evaluation.

In the problem of intestinal obstruction, the points of primary consideration are, just what happens when the bowel is completely occluded and what are the factors giving rise to our findings? Are the symptoms which develop due to toxic absorption?

When the small bowel is occluded there is, of course, an obstruction to the natural flow of intestinal material. Hyperperistalsis follows at once in an effort to overcome the obstruction. The entire gastrointestinal tract is affected at first. This is exerted not only on the upper segment but on the lower segment as well, which results in emptying of the lower segment before the classical signs of actual obstruction develop. This is just my own impression.

The result is that after the emptying of the lower bowel of the gas and intestinal material which is naturally there, this hyperperistaltic action subsides in this portion because of the fact that the gut is empty. In the upper segment above the obstruction, however, the obstruction still remains, and therefore, there is still the tendency of the peristalsis to try to pass material beyond the obstruction. There results a distention of this proximal loop of bowel with gas. This is a phenomenon that has been observed by all. Everyone recognizes gas distention of the bowel as one of the cardinal signs in the diagnosis of intestinal obstruction.

Just where the gas comes from is not fully understood by physiologists today. I hardly believe that it could be due entirely to air that is swallowed during nausea, because of the fact that the gas is not essentially nitrogen and it would have to be if it were air that was swallowed. Likewise it is not essentially due to fermentation because it is not carbon dioxide Whether it is due to the products of putrefaction is a difficult problem to determine. It is very probable that it may be due in part to putrefaction or due to the fact that there is some interference with the normal gaseous interchange in the bowel. Experimental work has definitely established that such an interchange exists. Within a very short time after complete occlusion of the bowel from one to four hours, depending on observation of different investigators, fluid begins to form in the gas-distended bowel.

I think that while we must, of course, give proper attention to all investigative work in this regard and give it its proper place, we must not overlook our own clinical investigations and our own clinical observations. It is the experience of everyone that vomiting is preceded by nausea, and that prior to the actual act of vomiting, there is hypersecretion of the salivary glands. A similar process probably goes on in the rest of the gastrointestinal tract with hypersecretion into the gut. This probably results in the development of fluid levels throughout the gas-distended bowel. This is our second prominent sign in the diagnosis of intestinal obstruction with the roentgen ray.

Possibly this is just nature's effort to rid itself of the toxic products. Perhaps it just pours its own secretions into the gut in an effort to reduce the intoxication and rid itself of this toxic product. At any rate, it seems logical to suppose that is the case.

As to what the gaseous distention comes from it is very difficult to say with any degree of certainty, but that distention of the bowel alone may produce every symptom of obstruction was obvious to us from an experiment that we did a number of years ago. While in-

vestigating another problem in the pelvis we inserted balloons into the rectum and lower bowel, inflating them with air to various degrees, in order to see if we could visualize the pelvic organs. When the balloon was partially inflated, to the size of normal gut, the patient experienced just the natural desire to go to stool; with over-distention of the balloon, however, an unnatural pressure was exerted on the bowel, the patient experienced excruciating pain and nausea; in fact, experienced all of the phenomena of shock with feeble pulse, clammy sweat, etc. By deflation of the balloon and relief of the pressure on the bowel the symptoms immediately completely subsided. The whole process took only a few minutes; there was not time sufficient for the accumulation or the absorption of any toxin.

So, therefore, I think we are justified in considering this as a mechanical phenomenon, at least to a certain extent. That there is a toxic factor is to me quite evident from many clinical observations. For instance, I have seen a girl with complete intestinal obstruction, of several days' duration, become so toxic that she actually had a feeling of well-being, she didn't really feel badly at all and did not complain that there was anything wrong with her. I am sure you have all made similar observations. Then again, why should there not be toxic product formed? You have all seen the bowel at operation which had become gangrenous and dead; under such conditions putrefactive products are bound to occur which must necessarily have their toxic effect when injected so intimately into the circulation.

There is one thing which, it seems, we may glean from these observations: that there may be a difference in the roentgen findings in the paralytic type of ileus and in actual intestinal obstruction. Due to the fact that prior to the symptoms of actual obstruction occurring there is an emptying of the lower bowel of gas and intestinal material, the roentgen findings show the lower bowel devoid of gas and collapsed. The roentgenogram will show gas-distended loops of bowel above, the obstruction. Barium enema given to such a patient will show the lower bowel completely collapsed and of even smaller caliber than usual.

Clinically the insertion of the finger into the rectum will find it flaccid and relaxed and empty in the cases of actual mechanical obstruction; whereas, in the case of paralytic ileus, the same factor which has to do with the production of ileus elsewhere in the bowel also has its effect upon the production of the gas distention in the rectum and it will be ballooned out with gas.

Unfortunately the problem is not quite as simple as it sounds because of the close relationship of these two conditions. In going over a number of cases that occurred during a five or six year period in our hospital, we found that either of these conditions so frequently leads to the other after a while that often it was difficult, if not impossible, absolutely to differentiate as to which was the primary factor. You can readily see how the peritonitis that may result from an inflammatory reaction surrounding the primary obstruction may give rise to secondary ileus, and you can see how a primary ileus from some interference with nerve control may result in twisting the bowel and a subsequent secondary development of actual obstruction. If the cases are seen at the onset, it seems to me that this point should be of value in the differentiation of the two conditions in many instances.

Dr. Ross Golden, New York City. We are indeed grateful to Dr. Ochsner for this presentation of his anatomical and physiological study. The question of gas in the small intestine is of unusual interest. The statement is often made that gas is not present in the normal small intestine. One should define for himself what he means by the normal small intestine. Gas in relatively small quantities in my experience is rather frequently present in the small intestine, and in cases of abdominal pain, such as ureteral colic or acute lumbar myositis, there may be considerable gas in the small intestine. However, the width of intestinal loop in such cases seldom exceeds 2.5 or perhaps 3 cm.

Some five or six years ago Swenson and Hibbert at the Presbyterian Hospital in New York, made a series of experimental observations on dogs which agree beautifully with the conclusions expressed by Dr. Ochsner. They found that after a mechanical obstruction gas appeared in about three to three and one-half hours and fluid levels two to three hours later.

Dr. Ochsner's statement about the differential diagnosis agrees with our experience. Obstruction, paralytic ileus and mesenteric vascular occlusion will all produce the same picture as far as dilated loops are concerned.

Furthermore, Swenson and Hibbert showed that films taken of patients within twenty-four hours after an abdominal operation would invariably show gas-distended loops of the small intestine, and a diagnosis of intestinal obstruction within twenty-four or perhaps forty-eight hours after abdominal operation could not be made on that basis. They also showed that one could recognize with considerable certainty the level of the dilated loops. The striations in the jejunum appear quite distinctly in the gas-distended loops, while the ileum shows a smooth wall, and one can say in a roentgen report, for instance, that if intestinal obstruction is present its level is probably in the lower ileum, the upper ileum, or the lower jejunum or the upper jejunum. Our surgeons have found that to be of help. They sometimes plan their incisions upon the basis of that information.

Dr. Ochsner's advice to study these patients in this way is amply justified in our experience. For a number of years at the Presbyterian Hospital it has been routine whenever intestinal obstruction is suspected to have what we call a three-position abdomen study. One flat film of the patient lying supine on the Potter-Bucky diaphragm, and then a film with horizontal rays with the patient first turned on one side and then on the other.

Dr. E. P. Pendergrass Philadelphia. I am one of those who have said that gas in the healthy small intestine is not normal, and I think the point that Dr. Golden brought out was a very excellent one; namely, that we should qualify what we mean when we say normal small intestine. When I made that statement I referred to the experimental work that was done in healthy medical students. I did not refer to those who had reflex nerve stimulation or peritoneal irritation of any type.

You also know that in young children and in the new-born infant one finds a considerable amount of air or gas in the small intestine. When this gas or air disappears as a normal constituent of small intestinal content is still an unknown factor.

Dr. Golden has said that peritoneal irritation will cause gas in the small intestine. We have had that same experience in every type of small intestinal irritation. It may be sufficient to suggest an obstruction at times. It is not always as small in amount as he has indicated. I think it should be stressed that when roentgenologists are examining patients in whom there is an acute abdomen and there is a question of acute pancreatitis or obstruction, or some other trouble in the abdomen, they should inquire of the patient whether or not he has been given drugs. We know from our small intestinal studies that morphine, in fact any sedative, will cause gas to collect and remain in the small intestinal tract. I have seen cases in which two or three surgeons have been in agreement that the patients had an obstruction, and yet because of a difference of opinion among the consultants, the patients were not operated upon. These patients got well because morphine was the factor that was causing the acute distention of the small intestinal tract.

There is another point that I think we should remember, and that is if one does not examine the patient in the erect, the horizontal, and the posteroanterior horizontal with the patient lying first on one side and then the other, we as roentgenologists should not attempt to indicate to the surgeon the point of obstruction. In other words, one can get gaseous distention of the upper small intestinal loops and at operation the obstruction will be in the pelvis. That is due to the fact that there is fluid in the intestinal loops below that gas and we do not therefore see these small intestinal loops indicated on the roentgenogram.

Dr. Ochsner (closing). I am indeed grateful for the discussion. I think that Dr. Sante brought out an exceptionally good point, particularly in regard to the therapy in these cases. Too frequently the clinician will say, "This can't be a case of obstruction because the patient has had one or two bowel movements since the onset of the symptoms." As Dr. Sante has emphasized, that doesn't mean that the patient hasn't an obstruction, because not infrequently there is an increased peristalsis both below and above the obstruction. When such occurs the part distal to the obstruction is likely to be emptied, resulting in one or two defecations and one is likely to be misled as to the exact conditions.

Dr. Golden mentioned the possibility of gas occurring as a result of the passage of ureteral calculus. There are many different stages of ileus. The gas which occurs as a result of the opening of the abdomen, or the passage of ureteral calculus, or a blow on the abdomen, is an ileus; and it is due to the stimulation of the splanchnics, either indirectly through the stimulation of the peritoneum or directly by

stimulation of the splanchnics themselves.

One of the worst cases of ileus I ever had followed a lower-stage thoracoplasty, where undoubtedly we had irritated the splanchnic nerves during the course of the operation. As you know, ileus is likely to be associated with pneumonia. In such an instance, I am convinced it is due to direct involvement of the splanchnic nerve. We feel that every case that has a laparotomy, the mere opening of the abdomen, the handling of the peritoneum, the chemical trauma produces an ileus which we like to term a functional ileus. It lasts a relatively short period of time, probably eight to twelve hours, but it is just as true as the ileus that produces an adynamic variety.

I think that Dr. Sante raised a good point about the differentiation between the adynamic and the mechanical types of ileus, and it is very probable the introduction of barium might be of value. One of the difficulties is that just because there is an adynamic ileus doesn't mean that the entire bowel has to be involved. For instance, in an individual with appendicitis with inflammation the right iliac fossa will have an ileus of the cecum and the terminal ileus, whereas the rest of the bowel may not be involved. In other words, wherever the inflammation, there is likely to be the ileus, whereas the rest of the bowel may not be involved.

PERIAPICAL EMPYEMA

REPORT OF THREE CASES WITH NECROPSY FINDINGS

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From the Desert Sanatorium and Institute for Research
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THE literature contains only a few reports concerning periapical pleural empyema, "l'empyème du sommet" of the French literature. It was described first by Laennec, it was observed by Grisolle and Burney fifty years later, and, after a lapse of many years, a few reports appeared in the modern literature by Hartfall and Pyrah,[5] Bindschedler and Tassovatz,[2] Rigler,[7] Bowen,[3] Rienhoff and Davison,[8] Wessler and Jaches,[9] Barjon,[1] Dreyfus,[4] and others. There is no doubt that periapical empyema is rather rare and empyema in this localization presents clinical and roentgenological features that cause considerable diagnostic difficulties. While the diagnosis of a localized empyema, other than apical, is usually a matter of easy routine, an empyema encapsulated over the upper portion of the chest presents some peculiarities which give rise to differential diagnostic problems, so that in many instances the disease is not recognized before the fatal termination. The relative, true or apparent, rarity of the condition and its differential diagnostic interest may justify the report of the 3 following cases.

REPORT OF CASES

Case 1. E. S., white male, aged sixty-seven, admitted to Maybury Sanatorium July 26, 1922, complaining of weakness and cough. The family and past history present no pertinent data. About one year before admission he developed a slight, increasing cough which was soon followed by weakness and loss of weight. A few months later he noticed night sweats and pain in the upper portion of the chest. Six months before admission multiple swellings appeared near the base of the neck bilaterally; they were incised repeatedly in January, February and March. The incisions never healed and left sinuses discharging thin pus.

On admission the patient was moderately emaciated; he had discharging sinuses, surrounded by torpid granulation tissue, on each side of his neck near the base and a similar one in the suprasternal notch. There was a slight impairment of the percussion note over the upper outer portion of his right chest and some pleural rub in the right lower portion of the axilla. Otherwise no abnormal physical signs were elicited. A roentgenogram of the chest, taken October 25, 1924, showed the following: The diaphragmatic leaves are in the usual position, smoothly outlined, and the angles are clear. The left hilum presents some increase in size and density; otherwise, the left lung field is normally aerated. The right upper chest is slightly shrunken, the intercostal spaces being somewhat narrowed. Obscuring the apex and the upper lateral lung field there is a halfspindle-shaped area of increased homogeneous density; this shadow shows a sharp semicircular outline which is convex toward the pulmonary field and extends downward to the level of the second anterior rib. The root markings are moderately increased in size and density, extending far into the central lung field. There is some slight haziness obscuring the upper and middle lung fields, which probably represents a reduced aeration; the pulmonary markings in the infraclavicular triangle are slightly accentuated (Fig. 1). The blood count at this time showed a moderate secondary anemia, and a total white count of 15,000 with 77 per cent polymorphonuclears. The patient had very little expectoration, and tubercle bacilli could never be demonstrated in his sputum.

The clinical course was a slow, rather uneventful progression, with increasing anemia. Occasionally small amounts of albumin and a few granular casts were found in the urine. The temperature was mostly within normal limits, but, particularly during his last year of life, he had episodes of varying length during which his temperature was elevated up to 100° and 101° F. Physical signs indicated slight

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extension of the lesion in the right upper chest.

A roentgenogram taken April 7, 1926, shows the previously reported homogeneous shadow over the right upper lateral lung field to be increased in size, extending down to the level of the third rib. The apex is entirely obscured; the semicircular sharp outline toward the lung field is still present. No other appreciable changes, as compared with the previous film, are noticed (Fig. 2).

A biopsy taken from the granulation tissue, surrounding the sinuses, was diagnosed as tuberculous granulation tissue with secondary pyogenic infection.

The patient died in extreme emaciation on July 19, 1926.

The autopsy was performed eleven hours after death. The direct cause of death was congestive heart failure, with hypostasis and edema of both lower lobes, bilateral hydrothorax and edema of both lower legs and feet. There is an obliterative pericarditis with a small brown heart with dilatation of the right side of the heart. There is moderate amyloidosis of spleen, liver and adrenals.

The findings pertinent to this report are as follows: In the right pleural cavity there is an empyema densely encapsulated and extending from the second anterior rib to the upper thoracic aperture. It is confined to the anterior and lateral surface and the dome of the upper lobe. Both pleural leaves, and particularly the visceral, are markedly fibrosed and thickened. Over the extreme apex of the lung,

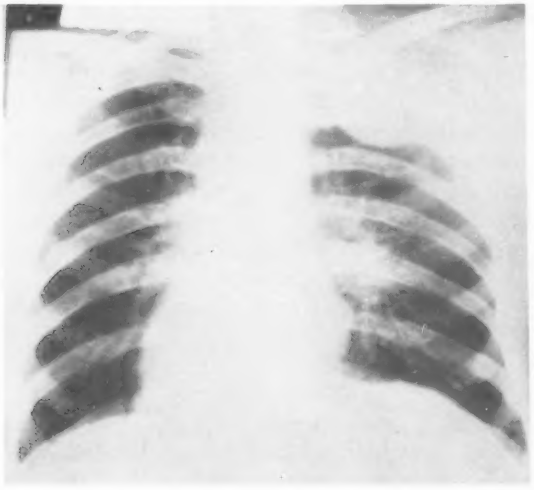

Fig. 1. Case 1. Roentgenogram taken October 25, 1924. Tuberculous empyema over right upper lobe.

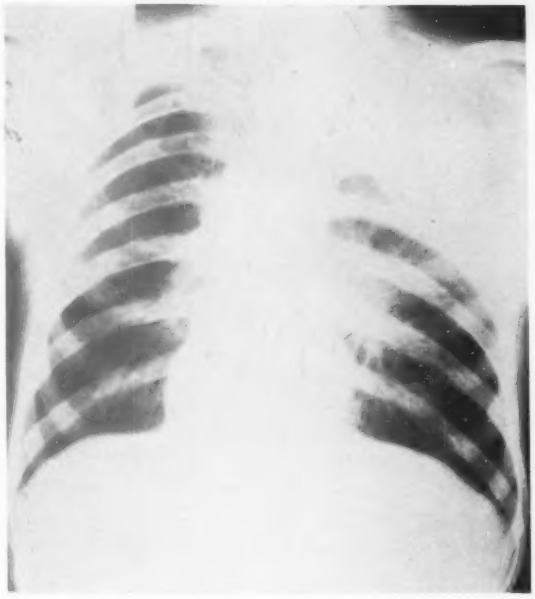

Fig. 2. Case 1. Roentgenogram taken April 7, 1926.

the two pleural leaves are fused into a mass of edematous, hyalinized, fibrous tissue, about 2 cm. thick. This empyema cavity is filled with viscous foul-smelling pus; it is in open communication with the cutaneous sinuses mentioned above. In the posterior portion of the empyema, the probe reaches into denuded and ulcerated bone, being part of the anterior and lateral surfaces of the first and second thoracic vertebral bodies. Similar ulcerations are found on the pleural surfaces of the bony portions of the second and third right ribs near their chondro-osseous junction. Directly above the tracheal bifurcation there is a lymph node, measuring about 2 cm. in its greatest diameter; it is firmly adherent to the tracheal wall, and the latter shows in its epithelium two 2–4 mm. retracted scars, just opposite the adherent lymph node. This lymph node shows on section a small dry caseous center. Near the base of the right lower lobe, slightly below its anterior surface, is a sharply defined caseous nodule, completely surrounded by a fibrous capsule; this node with the caseated lymph node described above, represents the primary complex, anatomically not healed. The retroperitoneal lymph nodes around the pancreas and the hepatic hilum are moderately enlarged and caseated, and one of these nodes has perforated into the first portion of the duodenum.

Summary of Case. The most likely patho-

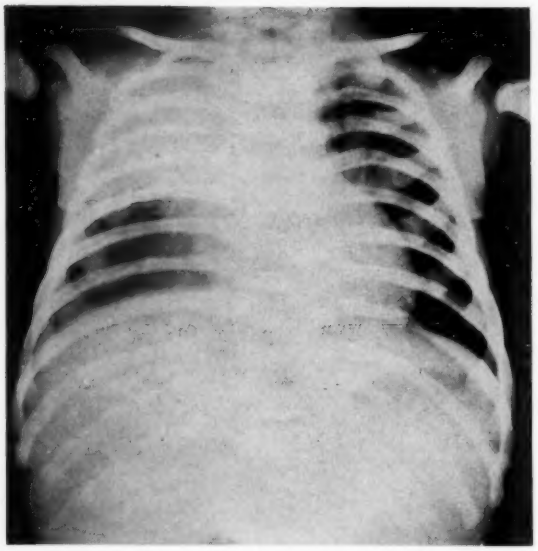

Fig. 3. Case II. Encapsulated apical empyema (*Staphylococcus aureus*). Roentgenogram taken July 29, 1932.

genetic development is as follows: The primary infection took place in the right lower lobe, leaving the unmistakable mark of the primary complex. The lymphoglandular component progressed slowly and led to the involvement of the ribs and vertebrae in the region of the empyema, either by ascending lymphatic infection followed by local extension into the bones, or, more likely, by a slow lymphatic-hematogenous spread, leading to the involvement of the bones and the retroperitoneal nodes. In any event, it is most likely that the pleura became secondarily infected from the osseous lesions, since no tuberculous foci could be demonstrated in the right upper lobe, nor any other place in the lung with the exception of the primary focus. The tracheal perforation, apparently healed at the time of the autopsy, must obviously have developed as a progression by direct continuity from the lymphoglandular part of the primary complex. There is nothing in the patient's history that could be associated with this event. That not every tuberculous perforation into the trachea or into a larger bronchus causes parenchymal involvement is well known.

Case II. M. A., female baby, aged four months, has not been in perfect health since her birth in February; this has been attributed to difficulties in feeding. During May and the early part of June, 1932, the child had a slight coryza which was followed by cough and fever for a few days. There were râles throughout the right chest. Following a short period of apparent improvement the child became acutely ill with high fever, cough, difficulties in breathing and cyanosis. In the third week of July, the child was first seen and the physical examination at that time showed dullness over the right upper thoracic area with a localized patch of diminished breath sounds anteriorly, and tubular breath sounds in the axilla and posteriorly. At this time, the white count was 27,000 with 80 per cent polymorphonuclears and a marked shift to the left. A tuberculin test was negative to 1/100 mg. ofold tuberculin.

Roentgen examination (July 29, 1932) showed a dense shadow over the right upper lung field, apparently confined to the upper lobe. There was a slight shifting of the upper mediastinum to the right side. There were no pulmonary markings discernible in the obscured area. The remainder of the lung field, the pleura and the diaphragm failed to show any changes (Fig. 3). At this time the preliminary diagnosis was: consolidation of the right upper lobe of probably pneumonic character, or atelectasis due to some bronchial obstruction. During the next three days the child looked a little better. Although the diagnosis did not seem definite, it was felt at that time that on account of the long period of illness, the emaciation and the history, tuberculosis had to be considered in spite of the hematological findings. A lobar pneumonia seemed improbable on account of the duration of the disease and on account of the relatively low temperatures of 101.8° F. There was no evidence of a miliary spread which might have explained the leukocytosis. On August 3, a physical examination showed a marked change for the worse: the child's respiration was irregular, Cheyne-Stokes in character. The percussion note over the whole right chest was dull, no râles could be heard; high in the axilla the breath sounds were harsh and frankly tubular. The liver edge could be felt 4 cm. below the costal margin, either indicating that the liver was enlarged or pushed down into the abdominal cavity. The white cell count had risen

to 56,800, with a marked shift to the left and profound toxic changes, both in the granulocytes and lymphocytes.

Roentgen examination (August 3) showed a complete density obscuring the right upper pulmonary field and a few hazy circular shadows throughout the lower parts of the right lung; the cardiophrenic angle on the right side was obscured, suggesting the possibility of a small pleural effusion (Fig. 4). The child died the following night.

The autopsy was performed eight hours after death. The body is moderately emaciated with pale atrophic and dry musculature. Only the thoracic organs reveal any pertinent findings. The entire right upper and the middle lobes of the lung are surrounded by a fairly thick mantle of yellow pus. This pus, amounting approximately to 200 c.c., is confined to the intrapleural space. The empyema pocket is surrounded by granular, thickened pleura with many necrotic tags. Medially the pocket is formed by the adjacent pericardium which shows the same changes as the pleura. Fibrinofibrous adhesions form a capsule that is impervious to the pus. The right upper and middle lobes contain many areas of dark red granular consolidation which occupy more than half of the parenchyma. In the upper lobe some of these areas show central liquefaction, presenting smooth-walled abscess cavities filled with yellow pus. The lower lobe is partly collapsed.

Histological studies confirm the diagnosis of multiple purulent bronchopneumonia with central abscess formations and fibrinopurulent pleuritis. The etiological agent, as demonstrated in smears, sections and pure cultures, was a *Staphylococcus aureus*.

Summary of Case. It is not easy to interpret the clinical course in terms of the autopsy findings. It is uncertain at what point of the history the major pathological alterations developed. But knowing the acuity of staphylococcal infections in the lung and in the pleura, it seems safe to assume in combination with the clinical findings, that these major changes were well developed by the time the child was first seen. There is probably little doubt that the pulmonary lesions developed first and that the empyema presents a direct extension from the former. The high leukocytosis should not be misleading; it occurs not infrequently in purulent staphylococcal infections; and the hematological diagnosis of leukemia is not made on the basis of the total white count but on the basis of the morphology of the blood. In spite of the absence of a definite mediastinal shift to the uninvolved side, the homogeneous density should probably have been sufficient evidence to invite an exploratory thoracocentesis.

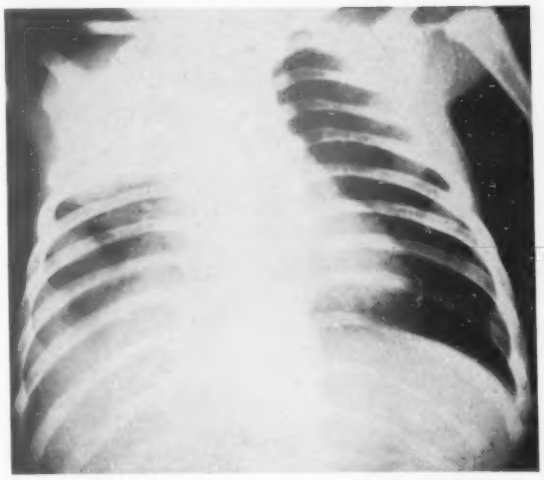

Fig. 4. Case II. Roentgenogram taken September 3, 1932.

Case III. S. A., male, aged eighteen months. This child first became ill on April 12, 1935, with fever and wheezing cough. There was a slightly grunting respiration which, however, disappeared when the child was asleep. The temperature was 102° F. rectally. No other abnormal findings were elicited on the first day, with the exception of a mild pharyngitis. On the second day the respiration was obstructive in type; the temperature remained the same. On the third day of the illness, the child was found in marked respiratory stridor with inspiratory retraction of the intercostal spaces. Scattered râles were heard over the chest, but there was no evidence of a localized pneumonic lesion. The white count on this day was 11,000 with 58 per cent neutrophiles. In the afternoon a bronchoscopic examination was performed, but no definite abnormal findings, and particularly no foreign body, were reported.

Roentgen Examination (April 14, 1935). The

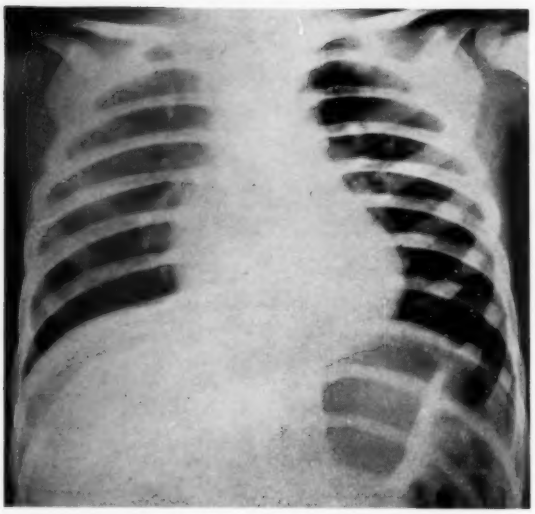

Fig. 5. Case III. Encapsulated apical empyema (Pfeiffer's bacillus). Roentgenogram taken April 14, 1935.

diaphragm is in the usual position, there is no change in the motility. The angles are clear. The right upper pulmonary field shows a very slight haziness, as compared with the left side; the lower right and the left pulmonary fields are normally aerated. The cardiac and mediastinal shadows show a suggestion of a slight shift to the right side. In the area of the right upper lung field the pulmonary markings are well visualized despite the obscuring haziness. The trachea is normal in size and course, and there is no evidence of a shadow due to a foreign body. There is no evidence of a persistent thymus or of any other abnormality in the mediastinal area (Fig. 5).

April 15, 1935, the stridor increased and the child died in the morning of the fourth day of his illness.

The autopsy was performed three hours after death. The body is well developed and in a good state of nutrition. The only pertinent findings concern the lungs and pleurae. The upper half of the right pleural cavity contains about 3 ounces of thin sanguino-purulent fluid that is spread in a thin layer around the upper lobe. Easily broken fibrinous adhesions are present around the base of the upper lobe, forming a competent, though tenuous encapsulation of the exudate. Both lungs are diffusely congested and contain, particularly in the lower and paravertebral portions, numerous patches, pea- to bean-sized, of granular consolidation. Many of these consolidated and airless areas show small central or perifocal hemorrhages; this is particularly prominent in subpleural foci. The air passages are normal and contain neither exudate nor foreign body.

Histologically the areas of consolidation are foci of hemorrhagic bronchopneumonia in which the interstitial exudate is relatively more prominent than the intra-alveolar exudate. The exudate consists chiefly of mononuclear cells and erythrocytes.

Smears from the encapsulated fluid and from the parenchymal exudate show many tiny coccoid gram-negative rods. The same bacilli are seen in histological sections. These organisms are obtained in pure cultures in and on blood-containing media and are identified as Pfeiffer bacillus.

Summary of Case. The only roentgenological findings in this case were a slight haziness obscuring the right upper pulmonary field and possibly a slight mediastinal shift toward the involved side. The type of breathing drew the attention primarily to a possible obstructive lesion in the upper respiratory tract. The physical findings (scattered râles, no decreased percussion sound) pointed toward disseminated lobular pneumonias, but not toward a pleural exudate, while only the roentgenogical findings led to the suspicion of a right periapical empyema. The gradually increasing change of the child's condition for the worse did not allow any surgical procedure. The stridor is not satisfactorily explained by the autopsy findings, since there was nothing that produced a stenosis in the respiratory tract above the carina. The only possible explanation on purely morphological grounds is the assumption that, intra vitam, the inflammatory changes of the adjacent pleura may have produced some collateral edema in the trachea.

COMMENT

From the roentgenological point of view the cases reported above need further discussion. It is entirely in keeping with the literature on apical empyema that in our cases the differential diagnostic difficulties were so great that a definite intra vitam

diagnosis was not made in 2 of our 3 cases. Dreyfus[4] described a case with similar clinical course and roentgenological findings. A child, four and a half years of age, entered the hospital with a pneumonia and an exudative pleuritis on the left side and some scattered pneumonic lesions on the right. The left side was tapped repeatedly and yielded a sterile serous exudate. Both pneumonia and pleuritis subsided; repeated thoracocentesis of the lower left chest became unproductive of fluid. In spite of these developments, cyanosis developed, the temperature curve became septic in type and the general condition became critical. At this stage some dullness was elicited over the left upper lobe and a roentgenogram confirmed the existence of a pleural effusion over the left upper lung field. Thoracocentesis in the third intercostal space posteriorly yielded pus containing pneumococci. Following a rib resection and drainage the child recovered.

In this case the diagnosis was made intra vitam; the development of an apical empyema had occurred on the basis of previous pleuropulmonary involvement and pleural adhesions.

Reviewing the literature, Dreyfus finds only 14 cases of periapical empyema which had been reported since the first case by Laennec over one hundred years ago. Further studies concerning the occurrence of this lesion confirm the report of Dreyfus. There are only brief references in clinical and roentgenological textbooks and a few more case reports in the literature, amounting at the present time to barely over 20 cases.

Periapical empyema, as a particular form of encapsulated empyema, is confined to the upper portion of the pleural cavity, not always strictly to the anatomical pulmonary apex. The lower portions are usually free or nearly so; in later stages, a localized empyema may spread throughout the pleural cavity, and the roentgenological findings then show the typical picture. Periapical empyema may occur as a complication of any inflammatory process in either of the upper lobes or in the apex of a lower lobe. The empyema may be encapsulated at the anterior or posterior surface of an upper lobe or it may surround it like a complete coat. Periapical empyema is mostly observed in early childhood; only very few cases have been reported in adults. The early diagnosis is difficult, chiefly because the clinical picture of a pulmonary consolidation and of a pleural effusion in early childhood are much alike, and because both lesions may be coexistent, such as in our Cases II and III. As Wessler and Jaches[9] point out, the apical empyema may not be recognized for some time until the clinical symptoms render the true condition unmistakable. Likewise, the interpretation of the roentgen findings meets with difficulties. A pleural effusion distributed over the upper lobe may cast a shadow of the same density as a lobar pneumonia. The degree of the density depends upon the amount of fluid so that an incipient effusion with a very thin layer of serofibrinous fluid may be entirely transradiated. Furthermore it should not be forgotten that the roentgen ray casts a denser shadow of radiopaque objects which are close to the film, as compared with those at a greater distance from it. The large diameter of the aerated lung field produces a brightening of the shadow of a shallow layer of fluid which may be present. Such physical failure must be considered in many instances of pathological conditions in the upper lung field. In cases where there is only a pachypleurisy or a cortical pleurisy, representing a very thin layer of thickened pleura, the shadow cast by an apical empyema is very faint. Postmortem findings in periapical pleural involvements support the opinion that apical and cortical pleurisy are actually more frequent than recognized clinically.

Besides the cases of empyema of strictly periapical encapsulation there are also cases of encapsulated empyema which develop at a lower level of the pleural cavity and which gradually extend in an upward

direction toward the apex. A few cases have been reported and it seems that they are not infrequently associated with the development of multiple bilateral empyemata.

The roentgenological investigation is of the greatest value in detecting and localizing periapical empyema. The disease often calls for early surgical intervention. To ascertain the exact localization, roentgenoscopy and roentgenography at different angles should be used. Rigler[7] suggests the attempt to take roentgenograms with the patient in the upright and in the prone position, and, if possible, also with the patient lying on his side. The latter position shows the extent and the motility of the shadow. This is of the greatest importance in the early stages when the density, cast by the roentgen ray, fails to show the typical shape and well-defined outlines. Changes in the patient's posture and in the respiratory phases may help to distinguish parenchymal consolidation (pneumonia, atelectasis) from pleural effusions. In the earliest stages, there may be a slight shifting of the mediastinum toward the involved side, and later on, with increasing amount of pleural effusion, a more or less marked displacement toward the opposite side may occur, but this symptom is of doubtful value. Atelectasis, pneumonic infiltration and early stages of a pleural involvement are likely to cause a displacement toward the involved side. In one of our cases which presented an early pleural involvement, the homolateral shifting of the mediastinum was present. The diaphragm may either show normal outlines and respiratory amplitudes or changes in the level and motility may be seen, similar to those observed coincident with other lesions of the upper part of the lungs. Usually the lower lung fields are clear, except in cases where there is an extension toward the base, due to a generalization of the empyema or due to the presence of parenchymal lesions, as seen in our second case. As to the homogeneous density of a shadow caused by a pleural effusion, it must be remembered that under certain circumstances the appearance of the pulmonary markings within a diffusely hazy lung field should be interpreted rather as a pleural involvement than as a parenchymal infiltration. This sign is of no diagnostic help in cases where bronchopneumonic lesions or abscesses coexist with pleurisy. In our Cases II and III, the markings were visualized; the haziness obscured the entire upper half of the right lung field, the lower outline being fuzzy. The faint lower margin of the haziness may be ascribed to the presence of pleural fibrinous adhesions which form the lower encapsulation and which ordinarily fail to cast an appreciable roentgenological shadow. In our first case, the sharp delineation caused a roentgenological appearance consistent with intrathoracic tumor; but the presence of fistulae, the chronicity and the absence of mediastinal shifting argued for a chronic infectious process whose etiology was determined by biopsy.

The difficulties of a proper roentgenological interpretation in Case III were aggravated by the predominance of the functional respiratory symptoms, which detracted the attention from pleuropulmonary involvement to the likelihood of a stenosing lesion, such as an intratracheal or intrabronchial foreign body or a persistent thymus or some other condition that might compress the upper respiratory canal. The dyspnea, the stridor, the inspiratory intercostal retraction, as well as the circulatory impairment, are probably explained by the pressure which the intrapleural effusion exerted upon the adjacent mediastinal structures and by the relative pulmonary collapse below the empyema. The fact that such secondary symptoms may obscure the clinical picture and be misleading, as far as the diagnosis is concerned, emphasizes the significance of exploratory thoracocentesis in such cases.

The pathogenic factors which lead to a periapical localization remain in the realm of speculation. In the acute empyemata

of early childhood, preëxisting upper-lobe adhesions play hardly a part, while it may well be the most important factor in chronic empyemata of adults. The relatively greater respiratory expansion and the greater negative pressure in the upper portions of the pleural cavity may be important. But this explanation is not quite satisfactory *per se*, because if a physiological condition were the cause of this pathological phenomenon the latter should be frequent and not quite rare. That the etiological agent is not the determining factor is clearly shown by the variety of microorganisms that have been found both in the literature and in our small series of 3 cases.

SUMMARY

1. Three cases of periapical empyema are reported. The clinical, roentgenological, pathological and bacteriological findings are described and discussed in conjunction with the few cases reported in the literature.

2. The post-mortem findings seem to point to a more frequent occurrence of periapical pleurisy, as shown by the presence of apical pleural involvement in non-suspected cases.

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CLINICAL AND ROENTGENOLOGICAL STUDY OF LOW BACK PAIN WITH SCIATIC RADIATION*

A. CLINICAL ASPECTS

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LOW back pain associated with so-called sciatic radiation has been recognized for centuries as a clinical entity. The obvious localization of pain in the low back frequently associated with a deformity of the spine early led to the conclusion that the radiation of pain in the leg was produced by some pathology in the low back. Various explanations, such as myositis, joint infection, lumbosacral abnormalities or derangement of the sacroiliac joints, have each in their time held sway as the plausible etiological factor producing this clinical syndrome. In recent years, a revival of interest in the lower lumbar spine and the lumbosacral joint as the causative factor for this symptom-complex of sciatic irritation associated with low back pain has been stimulated by the possibilities of mechanical nerve irritation demonstrated anatomically by Danforth and Wilson, and substantiated clinically by Putti, Ayers and later Williams.

Recently we reported a clinical and roentgenographic study of 100 of the 447 cases presenting the clinical symptoms of low back pain with sciatic irritation seen in the University clinic in the year 1934 to evaluate, if possible, the importance of the lumbosacral joint in the development of this symptom-complex.

The purpose of this paper is to present the clinical features of low back pain with sciatic radiation and to report the results of our clinical study of the 447 cases as a prelude to the roentgenographic study of these cases to be reported by Hodges and Peck.

The clinical picture of this group is characterized by the onset, sudden or gradual, in an hitherto normal individual, of low back pain associated with a radiation of pain into the lower extremity along an almost constant pathway in the posterolateral part of the extremity, the buttock, the anterolateral and posterolateral part of the thigh and the anterolateral part of the leg and foot. The cases reported in this paper may be subdivided into three groups, all with low back pain and radiation into the lower extremity, but differing in the extent of radiation or deformity.

Group I demonstrates the so-called typical sciatic scoliosis characterized by the symptoms of low back pain with radiation usually along the described pathway in the lower extremity plus the development of a list of the trunk away from, or toward the affected side, rarely as in only 3 of our cases, the list alternating to one and to the other side. Group II represents the symptoms of low back pain, with radiation the full extent of the lower extremity without the list, or a history of a list. In Group III, low back pain is present with radiation of pain into one or both buttocks, associated with pain deep in the thigh. These three groups differ only in the extent of the radiation and the presence or absence of a list, and may be unified for the purpose of study into the one clinical entity of low back pain with sciatic radiation.

No pathological process that precluded the possibility of spontaneous return to normal function was included in this study, thus ruling out all cases of tuberculosis, tumors, osteomyelitis, etc.

CLINICAL SYMPTOMS

The similarity of the major clinical symptoms in this group of patients is so constant that there is no doubt that we

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are dealing with a definite clinical entity. The more characteristic symptoms are briefly:

(1) *Pain.* Pain is of course present in every case in the low back with the characteristic radiation of pain into the leg, seeming to center about the posterior sacroiliac region into the buttock, deep in the thigh in the posterolateral portion, then it follows the peroneal division of the sciatic nerve. The pain in the low back is generally constant, aggravated by motion or change of position. The radiation pain may also be constant or may be intermittent and brief in nature, brought on by a sudden unguarded movement. In our experience, no case has presented radiation of pain along the tibial nerve distribution and only 11 of the 447 cases have had radiation of pain on the mesial side of the thigh.

(2) *Guarded motion* of the spine is early assumed by the patient. Spinal motion is prevented as much as possible by unusual use of the arms in changing positions such as getting up from a chair, or turning over in bed.

(3) *Attitude.* In 39 per cent of this group, 173 cases, a list of the trunk was present, listing away from the affected leg in 125, and toward the painful side in 81. Frequently when the list was not present (233 cases, 61 per cent), there was a protective attitude on standing with the weight borne on the well leg, and the painful leg held in flexion and abduction bearing little weight. Commonly, the most comfortable attitude assumed by this group is to stand bent over the back of a chair or table with the weight borne on the hands, the affected leg flexed and abducted.

Signs. Certain clinical tests are of definite value in the diagnosis of this lesion. Some of these tests are time-honored and of proved value.

(1) Straight leg raising is usually limited, and generally more limited on the painful side, frequently producing pain in the low back in the lumbosacral or sacroiliac region. For years this has been regarded as evidence of contraction of the hamstring muscles, but may rather be due to the contraction of the lumbopelvic muscles, altering the tilt of the pelvis and producing an apparent shortening of the hamstring muscles.

(2) Patrick's sign—supposedly a test for sacroiliac joint involvement—of forced abduction of the flexed thigh producing pain in the sacroiliac region is not commonly present. Rarely also is pain present on compression of the iliac crests. These tests, if positive, tend to incriminate the sacroiliac joint as the seat of the lesion.

(3) Hyperextension of the thigh with the patient prone and the knee flexed, Nachlas' sign, frequently produces pain in the lumbosacral region, and is a test of the lumbosacral joint.

(4) A test which we have used frequently for the lumbosacral joint and found positive in this clinical group is the so-called prone thrust test. The patient lies prone, raises himself on his hands with elbows extended, dropping the pelvis toward the table as far as possible. This produces hyperextension of the spine and in itself is frequently painful or impossible to carry out because of pain in the lumbosacral region. If it is not painful in itself, with the patient relaxed in this attitude, a sudden thrust over the lower lumbar spine sharply increases hyperextension and frequently produces severe pain analogous to the patient's symptoms.

(5) Ober's sign has been followed in all cases in the past two years but was infrequently used in the cases recorded here. This test consists in attempting to adduct the extended abducted leg with knee at right angles, the patient lying on his side. The test is positive if the knee cannot be brought to the table but remains in an abducted position. The iliotibial band is contracted in these cases. Recent reports of Ober's operation, a high division of the iliotibial band in cases with a positive test, have demonstrated marked relief of symptoms.

(6) Sensory changes are infrequently present in the vast majority of cases. About

20 per cent of all of the cases present evidence of sensory disturbances. The 20 per cent do show mild hyperesthesia or hypesthesia over the peroneal distribution.

(7) Tenderness. Common sites of tenderness will be discussed later.

(8) Motor changes are exceedingly rare (muscle weakness probably due to disuse), present in only 12 cases with a true paralysis present in only 2 cases in the entire series.

(9) The Achilles reflex was definitely altered in 80 cases, or 18 per cent, these cases demonstrating diminution of Achilles reflex usually, and less frequently completely absent.

(10) Atrophy of one-half inch or more of the affected leg is frequently present in this group of cases, practically constant in the severe chronic case undoubtedly on a disuse basis.

CLINICAL FINDINGS IN 447 CASES

This brief résumé of the clinical symptoms and signs definitely classifies the clinical entity we have described. In our clinical study, an attempt was made to record statistically the outstanding clinical signs and symptoms, and to compare these clinical findings with the independent report of the review of the roentgenograms.

There were 251 males and 191 females recorded in this study. Their average age, varying from thirteen to eighty years, was 49.7 years. A few cases with prolonged symptoms of years' duration added somewhat to the average duration of symptoms in this group of 4.24 years. It is interesting to note that occupation seems to play a definite part in this clinical entity; 168 cases were recorded as housewives, 91 as unskilled laborers, 84 as skilled laborers.

Trauma was regarded as a definite factor in the production of symptoms in only 25 per cent of the cases; 86 cases had sudden onset of symptoms immediately after trauma and 29 had a gradual onset which they attributed to a preceding injury. Without a history obtainable of trauma, 42 cases had sudden onset with 288 cases a gradual onset of symptoms.

I. *Duration of Symptoms.* The type of symptoms were classified as:

(*a*) Those with a single attack, 15 cases.

(*b*) Recurrent attacks with intervals of complete freedom, 230 cases.

(*c*) Cases with constant symptoms, 108.

(*d*) Cases with constancy of symptoms plus acute exacerbation associated with radiation of pain to the leg, 92.

II. *Severity of Symptoms.*

In 183 cases the symptoms were recorded as mild.

One hundred sixty-five cases were temporarily incapacitated by the severity of the symptoms.

Eighty-four cases were incapacitated from their usual occupation.

Fifteen cases were completely incapacitated by the severity of the symptoms.

III. *Location of Symptoms of Radiation.*

Group I: 147 cases had right-sided radiation of pain with radiation through the described pathway to the foot, 49 to the thigh, and 5 to the buttock. In 1 case only was pain referred to the perineum. Group II: 167 cases had pain referred to the left leg with 119 cases with complete radiation to the foot, 40 with radiation to the thigh, and 8 cases with radiation only into the buttock. Group III: 133 cases had pain referred to both legs, with fewer cases, 52, proportional to the other two groups with complete radiation, radiation to thigh in 60, and to buttocks in 10. There were 3 cases of perineal radiation in this last group.

Table 1 illustrates the location of the radiation of pain and its numerical frequency in the various sites. It will be noted

TABLE I

Radiation of Pain in 447 Cases	Right 147 Cases	Left 167 Cases	Bilateral 133 Cases	
			Right	Left
Iliac crest	7	3	3	2
Posterolateral thigh	139	151	102	101
Anterolateral thigh	10	5	14	14
Calf and foot	93	119	55	58
Perineum	1	1	2	1
Adductor region	0	2	2	2
Gluteal region	76	88	57	59

that there is a characteristic pathway for this radiation arising from the region of the posterior spines of the ilium, over the buttock and trochanter, down the posterolateral and anterolateral surface of the thigh, the anterolateral surface of the leg and the foot. There are no cases in which the pain radiates to the medial or plantar surface of the foot or leg, and very few cases with pain radiating on the mesial surface of the thigh. This distribution of pain is not the distribution of the sciatic nerve. The buttock and upper thigh receives little enervation from the sciatic nerve so it would be difficult to explain the radiation in that region on a sciatic basis. The posterior tibial nerve, a large component of the sciatic nerve, is never involved in our cases in this radiation of pain.

On the other hand, the area of involvement is the so-called dorsal axial surface of the leg which is supplied by the postaxial nerves of the anterior divisions which compose the lumbosacral plexus. In our former paper, we presented the theory that there is embryological and anatomical evidence to substantiate the clinical findings presented here that the radiation of pain in this group of cases is not sciatic in nature but is typically a radiation of pain over the pathway of the postaxial distribution of the lumbosacral plexus, and could more properly be called postaxial plexalgia.

Table II demonstrates the frequency in which lumbosacral tenderness and tenderness just beneath and lateral to the posterior spines of the ilium occur. Lumbosacral tenderness is not an uncommon finding in patients with just a low back pain, whereas the tenderness about the sacroiliac region is seen chiefly in this syndrome. Tenderness over the sciatic exit is also a frequent finding in this series.

TABLE II

Site of Tenderness in 447 Cases	Number of Cases
Lumbar spine	63
Lumbosacral	260
Posterior iliac spines	212
Lumbosacral articular facets	33
Sciatic notch	195
Deep nerve	66
None	53

TABLE III

CLINICAL FINDINGS

	447 Cases Studied	173 Cases with List	274 Cases without List
Achilles reflex changes:			
Right	40	25	15
Left	22	9	13
Bilateral	18	7	11
18.5 per cent			
Sensory changes:			
21 per cent			
Hypesthesia	57	31	26
Hyperesthesia	19	8	11
Numbness	12	10	2
Tingling	6	5	1
None	365	128	237
79 per cent without changes			
Radiation of pain:			
Right	147	72	75
Left	167	79	88
Bilateral	133	22	111
Protective attitude:			
Flexion of leg	71	57	14
Abduction of leg	20	16	4
Type of symptoms:			
Single attack	14	5	9
Recurrent	235	88	147
Paroxysmal	3	1	2
Constant	108	46	62
Constant with exacerb.	92	33	59
Severity of symptoms:			
Mild	183	54	129
Temp. incapacitated	165	73	92
Incap. usual occupation	84	39	45
Totally incapacitated	15	7	8

The report on the roentgenographic findings and the classification by Hodges and Peck will be presented by them. We have felt that the clinical findings compared with the roentgen findings might demonstrate a correlation of symptoms with the different type of roentgen changes. The following tables show definitely, however, that the symptomatology is characteristi-

cally the same whether the roentgenogram shows a normal spine, congenital malformations, narrowing of the lumbosacral joint space, arthritis, or asymmetrical development.

Table III illustrates the type of pain radiation noted in comparison with the various roentgen subdivisions. The predominance of radiation through buttock, thigh and into the leg, next into the thigh and lastly into buttock alone is in the same relative numerical proportion throughout the various subdivisions. That the type of skeletal change observed in the roentgenogram has no definite control over the extent and location of the radiation of pain seems a logical conclusion from study of this table.

Table IV

COMPARISON OF PAIN RADIATION WITH ROENTGEN FINDINGS

447 Cases Studied	Right			Left			Bilateral		
	Leg	Thigh	Buttock	Leg	Thigh	Buttock	Leg	Thigh	Buttock
Normal Lumbosacral Spine	8	11	1	20	11	1	7	10	3
Abnormal Lumbosacral Spine	85	38	4	99	28	7	45	50	7
Facet Type:									
Normal	56	29	2	61	21	5	26	32	5
Bilateral sagittal	6	1	0	13	1	0	10	2	0
Asymmetrical	18	13	2	28	5	2	3	12	4
Indeterminate	13	6	1	18	13	1	13	14	1
Facet Changes:									
None	65	40	4	96	24	6	35	39	7
Developmental	8	2	0	7	4	2	6	1	1
Acquired	8	2	0	5	1	0	2	6	0
Indeterminate	12	5	1	11	11	0	9	14	2
Intervertebral Spaces:									
Normal	35	27	5	50	18	3	20	33	5
Reduction L IV-V	6	2	0	3	1	0	1	2	0
Reduction L V-SI	49	19	0	60	17	4	27	25	5
Reduction L IV-LV-SI	3	1	0	7	3	1	4	0	0
Position Vertebral Bodies:									
Normal	88	38	4	113	37	6	43	55	9
Spondylolisthesis L IV-V	0	0	0	0	0	0	0	0	1
Spondylolisthesis L V-SI	3	1	1	6	3	2	6	3	0
Congenital Malformations:									
None	70	38	5	86	28	5	37	43	6
Sacralization	5	1	0	7	3	0	2	5	1
Lumbarization	4	0	0	7	0	0	1	0	1
Butterfly processes	1	2	0	1	1	0	1	1	0
Spina bifida	7	6	0	11	5	1	7	6	0
Hypertrophic Changes:									
None	72	39	4	94	29	7	34	47	8
Generalized	7	5	1	9	4	1	5	1	1
Local fringes, body	6	2	0	12	4	0	8	7	0
Local fringes, facet	4	1	0	3	1	0	3	4	1
Sacroiliac	4	2	0	3	3	0	4	3	0

Table IV compares the site of tenderness with the various roentgen subdivisions. The clinical tenderness noted over the lumbosacral joint is relatively the same whether the joint appears normal in the roentgenogram or demonstrates gross abnormality. The other points of tenderness similarly are in proportion to the frequency of the number of cases falling into the roentgen subdivisions. One might anticipate in this comparison that the cases with marked lumbosacral pathology would demonstrate the greater preponderance of cases with lumbosacral tenderness, which did not prove to be true.

Table V correlates the neurological symptoms, protective attitudes, and type and severity of symptoms with the roentgen subdivisions. It will be noted that in the relatively few demonstrating diminution or loss of the Achilles reflex, a preponderance occurs in those cases presenting abnormal roentgen findings, particularly in reduced lumbosacral space group. Although the number is too small to draw conclusions, it seems plausible that a true neuritis is more apt to occur with definite lumbosacral pathology. The sensory changes also occur with greater frequency in the abnormal roentgen group than in the normal. The remainder of this table shows very little evidence of any influence on the symptoms by any of the roentgen subdivisions.

TABLE V

SITE OF TENDERNESS

		16.3%	83.7%	57.2%	42.8%	27.1%	23.7%	21.9%
Site of Tenderness	447 cases studied	73 with normal x-ray	374 with abnormal x-ray	256 with reduced space	191 with normal space	121 with congenital malformation	106 with arthritic changes	98 with facet assym.
None	53	10	43	31	22	11	14	11
Lumbar spine	63	9	54	43	20	22	17	11
Lumbosacral	260	46	214	149	111	72	58	57
Lumbosacral articular facets	33	4	29	18	15	15	7	5
Posterior iliac spines	212	33	179	119	93	63	47	50
Sciatic notch	195	30	165	109	86	45	48	38
Deep nerve	66	12	54	39	27	17	15	16

CONCLUSIONS

Our conclusions in the clinical and roentgenographic study of 447 cases of low back pain with sciatic radiation are as follows:

(1) The striking preponderance of narrowing of the lumbosacral intervertebral disc occurring in 256, or 57 per cent, of these cases is a significant factor in the production of the symptom-complex.

(2) The 73 cases with normal roentgen findings which are included in the 191 cases, or 43 per cent, with normal intervertebral joint space present exactly the same clinical phenomena with the exception of less evidence of true neuritis as demonstrated by Achilles reflex changes and sensory changes.

(3) The conclusion that superficial tenderness over the lumbosacral or sacroiliac area is indicative of skeletal changes in the underlying joints seems to be questionable in view of the same relative frequency of this tenderness in cases with roentgenograms of normal spines as in the cases with abnormal roentgen changes.

In conclusion, it is our theory derived from these studies and expressed in our former paper, that low back pain with radiation of pain into the leg is a clinical syndrome arising from a primary lesion in

TABLE VI

CLINICAL FINDINGS

			16.3%	83.7%	57.2%	42.8%	27.1%	23.7%	21.9%
		447 cases studied	73 with normal x-ray	374 with abnormal x-ray	256 with reduced space	191 with normal space	121 with congenital malformations	106 with arthritic changes	98 with facet assym.
Achilles Reflex Changes	right	40	4	36	27	13	10	8	9
	left	22	2	20	15	7	5	9	4
	bilateral	18	2	16	9	9	7	6	2
List	homolateral	73	12	61	46	61	21	12	17
	contralateral	97	11	86	63	35	26	19	38
	scoliosis	41	7	34	27	14	13	10	14
Sensory Changes	hypesthesia	57	8	49	40	17	13	16	10
	hyperesthesia	19	2	17	10	9	8	5	7
	none	365	63	302	202	163	99	83	81
Radiation	right	147	20	127	80	67	34	32	33
	left	167	32	135	97	70	47	37	35
	bilateral	133	21	112	79	54	40	37	30
Protective Attitude		75	10	65	45	30	19	15	14
Type of Symptoms	single attack	15	4	11	7	7	1	2	3
	recurrent	230	44	186	124	106	56	51	55
	paroxysmal	3	0	3	3	0	0	2	0
	constant	108	14	94	63	45	31	29	23
	constant with exacerbations	92	12	80	59	43	33	22	17
Severity of Symptoms	mild	183	31	152	102	81	47	43	43
	temporarily incapacitated	165	24	141	98	67	46	34	36
	incapacitated usual occupation	84	18	66	44	40	23	25	15
	totally incapacitated	15	0	15	12	3	5	4	4

the lumbar, lumbosacral, or sacroiliac region, muscular, joint or skeletal in origin, producing a radiation of pain by a referred mechanism which is typically postaxial in its distribution. The lack of evidence of true organic nerve injury in the majority of cases, 79 per cent, is in favor of referred pain. The predominance of reflex changes and sensory changes in the cases showing narrowing of the lumbosacral disc suggests in this type of lesion direct irritation of the nerve roots may develop in addition to the referred pain. The area of tenderness may also be the result of referred pain through irritation to the sensory nerves of the ligamentous structures rather than indicative of underlying joint pathology.*

* For discussion see page 466.

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CLINICAL AND ROENTGENOLOGICAL STUDY OF LOW BACK PAIN WITH SCIATIC RADIATION*

B. ROENTGENOLOGICAL ASPECTS

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IN CONJUNCTION with the Department of Bone and Joint Surgery of the University Hospital, the Department of Roentgenology has attempted to discover what, if any, roentgen findings are significant in the examination of patients presenting the symptom-complex which consists of pain in the low back with radiation along the course of either or both sciatic nerves. In the immediately preceding paper, Dr. Carl E. Badgley has described in detail the clinical manifestations and the objective physical findings characteristic of this symptom-complex. It has been our concern to conduct adequate and uniform roentgenological examinations of these patients and to record impartially any tangible objective deviations from the ideally normal anatomical relationships in the lumbosacral region.

Our observations are based upon the routine roentgen study of the dorsal, lumbar, and sacral spines of the 447 individuals used by Dr. Badgley and his group in their study. All of these individuals presented the combination of symptoms under discussion. For purposes of comparison, comparable spine films of a control group of patients were reviewed. This case material was obtained from the film records of patients who had been subjected to routine roentgen examination of the spine during the last year. The films of all patients complaining of any degree of radiating pain along the sciatic nerves were discarded, although in this control group of 538 individuals there were 353 who did complain of simple back pain. The average age of the control group was 38.7 years, or very nearly that of the group with sciatic radiation.

TECHNIQUE

Some statement regarding the technical procedures employed in these examinations is necessary, for without an established routine method of procedure it is impossible to compare roentgen observations on groups of individuals with any degree of accuracy. Some of the observations which seem to us to be of importance depend to a considerable extent upon the clarity with which certain structures can be visualized.

For several years we have followed a standardized routine procedure in examining patients referred for study of the vertebral column. Although the cervical spine is not included unless specifically requested, the four exposures which constitute this standard examination yield frontal and lateral plane views of all vertebral segments below the fourth cervical, including the sacrum and coccyx. The examiner is thus provided with an opportunity to observe the spinal column as a whole. All routine examinations are conducted with the patient in the horizontal position.

The first of the anteroposterior projections, including the entire pelvis and sacrum, the entire lumbar spine, and at least one dorsal body is carefully centered on one 14″×17″ film. The technically disadvantageous posterior curve in the lumbar region is offset by elevating the knees with a pillow. The second anteroposterior exposure, including the lowermost cervical segments, the entire dorsal spine, and at least one lumbar segment is carried out in a similar manner, employing a well-centered 7″×17″ film.

For examination in the direct lateral projection, the patient is placed on his side

* From the Department of Roentgenology, University of Michigan. Read at the Thirty-seventh Annual Meeting, American Roentgen Ray Society, Cleveland, Ohio, Sept. 29–Oct. 2, 1936.

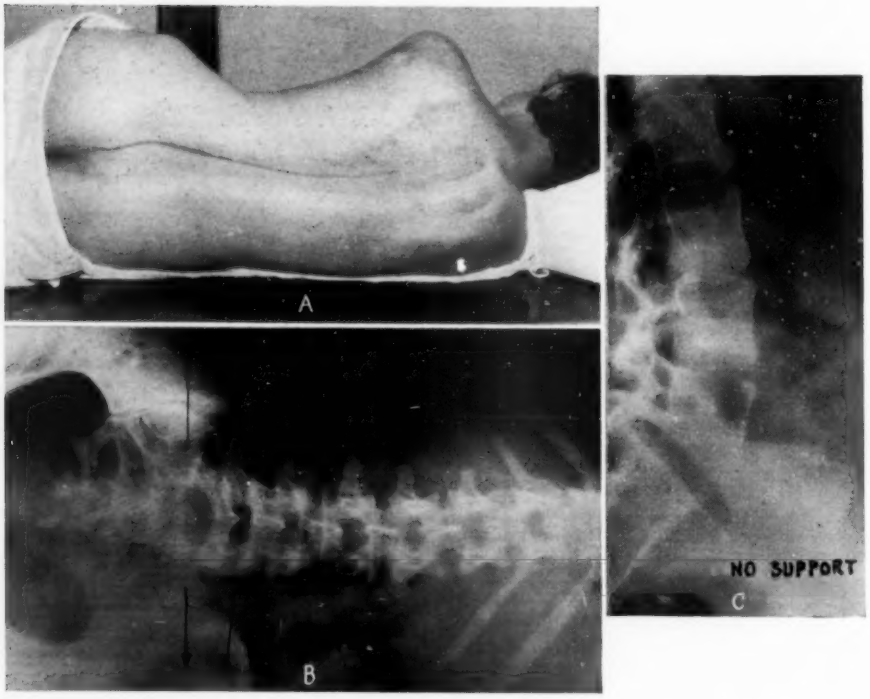

Fig. 1. *A.* Improper positioning of patient for lateral projection of lumbosacral spine. *B.* Anteroposterior projection made without changing patient's position showing natural sag of lumbar spine. *C.* Lateral projection made without changing patient's position showing confusing overlapping of vertebral body shadows.

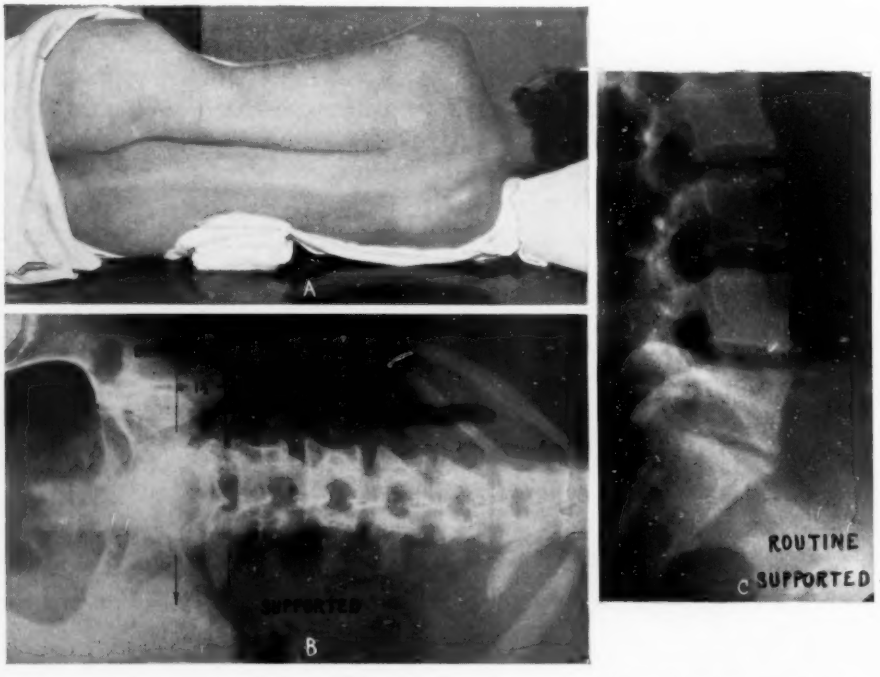

Fig. 2. *A.* Proper position of patient for lateral projection of lumbosacral spine. *B.* Compare with Figure 1*B*. *C.* Compare with Figure 1*C*.

with the knees and hips flexed and supported with a pillow and sand bags. The arms are held forward in a similar manner. By means of padding between table and patient, the normal sag of the dorsolumbar spine is overcome until a line joining the spinous processes parallels the plane of the film (Figs. 1 and 2). The first of the two lateral projections includes the entire dorsal spine and the immediately adjacent cervical and lumbar bodies. The final projection, most difficult of all technically and most helpful to the examiner, includes the entire lumbosacral spine and at least one dorsal body. Both lateral views are prepared on 7″×17″ film.

To insure maximum uniformity of photographic quality, exposure time, target-film distance, and tube current are maintained at constant values; the sole variable, kilovoltage, is determined by thickness of the body measured at standard points for each projection. All four exposures are made through a moving Potter-Bucky diaphragm, and intensifying screens of average speed are used.

In addition to this routine procedure as described, exposures are made with a narrowly restricted beam and small film when particularly fine detail is sought at some specific vertebral level. Stereoscopic exposures in right and left oblique projection, though somewhat difficult to prepare satisfactorily, are sometimes of great value in studying the posterior articulating facets. Anteroposterior stereoscopic exposures of the lumbosacral juncture, when prepared by directing the beam toward the film along the exact angle formed between the plane of this joint and the vertical axis of the patient's body, provide the observer with an excellent opportunity to study details of structure in this important region (Fig. 3).

Although the special examinations described were employed in the study of some of the cases here reported, it is true that they merely supplied confirmatory or detailed evidence of conditions recognizable in routine films.

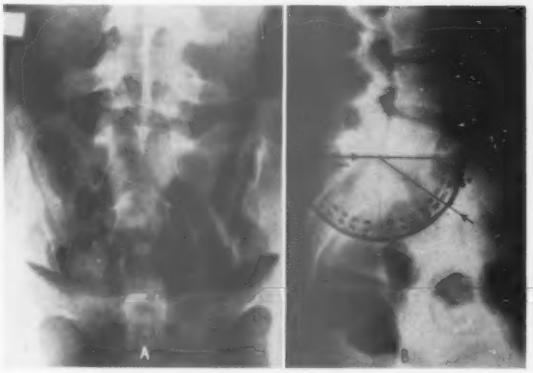

Fig. 3. *A.* View of lumbosacral joint as projected in the anteroposterior axis of the intervertebral disc at this level. *B.* Method of determining proper angle of projection from routine lateral projection.

Roentgenological Observations

Selected by case number in advance, purely on the basis of the presenting symptom of low back pain with sciatic radiation as determined by the Department of Bone and Joint Surgery, the routine film records of 447 individuals were withdrawn from files and carefully reviewed in a systematic manner. This review was conducted entirely independently of the surgical staff for whom the observations were tabulated according to a pre-arranged code consisting of ten major divisions within which details were listed.

First Division. All cases were designated as normal or abnormal from the roentgen viewpoint.

Second Division. The articular facets at the lumbosacral junction were described as the usual frontal type or some developmental modification.

Third Division. Developmental defects and acquired changes of the lumbosacral facets were noted.

Fourth Division. Alterations in posture of the lumbar spine and sacrum were noted and classified.

Fifth Division. The vertical diameter of the lumbosacral joint space was observed. If found to be no more than one-half the width of the space directly above, it was recorded as narrow; the degree of narrowing, if any, being noted. If only the pos-

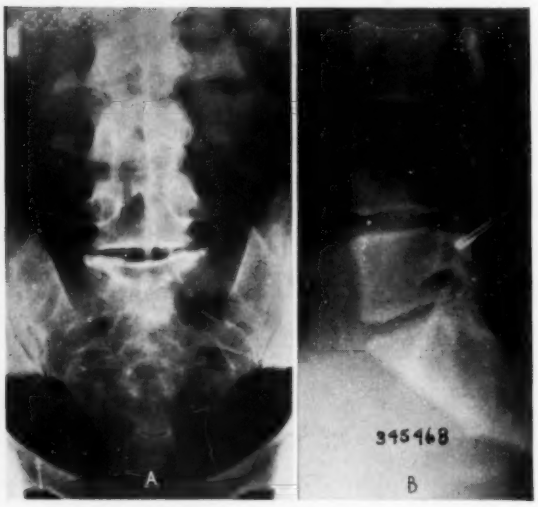

Fig. 4. Example of symmetrically narrowed lumbosacral intervertebral disc. *A.* Anteroposterior projection along joint axis. *B.* Routine lateral projection.

terior portion appeared narrow this fact was reported.

Sixth Division. Spondylolisthesis or other type of faulty alignment of vertebral bodies was described if present.

Seventh Division. The various anomalies such as sacralization, lumbarization, butterfly-type of transverse process and spina bifida were recorded in detail when observed.

Eighth Division. Fractures and dislocations were listed, specifying whether body, spinous or transverse process, facet, or sacroiliac joint was involved.

Ninth Division. Hypertrophic changes in bone were reported in detail, generalized involvement being separated from local fringing of body, facet, sacroiliac joint. Unilateral changes were recorded as right or left.

Tenth Division. Miscellaneous changes not included in the above group were recorded here. Evidence of inflammatory bone or joint disease without proliferative change, signs of tumor whether primary or metastatic, calcification of the iliolumbar ligaments, and other miscellaneous changes were qualified as to the particular structure involved.

Dr. Badgley and his group have attempted to correlate these numerous roentgen observations with similarly detailed findings derived from physical examination of the same patient group. Without intimate knowledge of the individual clinical details of each patient's condition, the roentgenologist is at a distinct disadvantage in attempting to evaluate the probable significance of highly localized or lateralized anatomical changes. He must content himself with faithfully reporting such changes without prejudice. However, upon reviewing this mass of roentgenological data with the aid of mechanical tabulating equipment, we were impressed with several outstanding findings which seemed to have been present with most unusual frequency among these cases.

We had reported the intervertebral disc at the lumbosacral junction to be definitely narrower than the discs immediately above this level in 220 patients, or 57.2 per cent of the group (Figs. 4 and 5). Our tabulated results showed a total of 121 instances of developmental anomaly in the lumbosacral region, an incidence of 27 per cent. Visible expressions of osteoarthritis involving lumbar spine, sacrum, or sacroiliac joints had been observed in 106, or 23.7 per cent of the group.

Fig. 5. Example of asymmetrically narrowed lumbosacral disc. *A.* Anteroposterior projection along joint axis. *B.* Routine lateral projection.

It is necessary, of course, to compare under similar circumstances of examination the occurrence of these outstanding findings in patients who do not complain of similar symptoms. Since, in this department, the roentgen findings in all patients examined are routinely catalogued on punch cards, it was entirely possible to tabulate the observations already recorded on the control group described earlier. Fortunately, narrow lumbosacral disc, anomalies of any degree, and osteoarthritic changes whenever seen have for over two years been faithfully catalogued. The results of this control study are recorded in Table 1. It will be seen that narrow lumbosacral disc is recorded in 57.2 per cent of the study group as against 12.8 per cent for the controls, a ratio of approximately 4.5:1. Lumbosacral anomalies of all types and degree occurred in 27.0 per cent of the study group as against 14.3 per cent of the controls, a ratio of approximately 2:1. Osteoarthritic changes, on the other hand, are seen with nearly equal frequency in both groups, a slightly higher number of cases being recorded among the controls.

The finding of narrow disc is undoubtedly to be expected in the case of patients showing evidence of bilateral or even unilateral fusion of the fifth lumbar vertebra with the sacral mass (Fig. 6). In the presence of spondylolisthesis, the strikingly altered relationship of bony elements may well be expected to be accompanied by disc disturbances. Fractures of the bodies of the lowermost lumbar bodies immediately suggest the likelihood of associated disc trauma and subsequent loss or displacement of disc substance with subsequent narrowing. All of these skeletal changes

Fig. 6. Example of narrowed lumbosacral intervertebral disc associated with unilateral sacralization of fifth lumbar segment. *A*. Anteroposterior projection along joint axis. *B*. Routine lateral projection.

combined, however, were encountered too infrequently to explain the high incidence of narrow lumbosacral disc. Beadle,[1] in his exhaustive monograph on the subject of intervertebral discs, describes the very numerous frailties of these structures. It may well be that, as he has suggested, minimal but oft-repeated trauma over a period of years, plus the changes due to senility, which he describes as beginning at an unusually early age in the discs, are significant etiological factors.

Wagner[3] has presented collected case reports to substantiate the significant relationship between disabling pain in the lumbosacral region and demonstrable skeletal and disc changes at the same site.

Williams[4] reported an even higher oc-

Table I

ROENTGENOLOGICAL OBSERVATIONS

Frequency of Outstanding Abnormalities Lumbosacral Region

Study Group		Controls	
447 patients (low back pain and sciatic radiation)		538 patients (no sciatic radiation)	
Narrow lumbosacral joint space	57.2%	12.8%	4.5 to 1 ratio*
Lumbosacral anomalies	27.0%	14.3%	2 to 1 ratio*
Osteoarthritic changes	23.7%	28.0%	No significant difference

* Approximate ratio between study group and controls.

currence of disc narrowing in an earlier and smaller group of patients with similar symptoms studied at this institution. He explained the characteristic complaint of peripherally radiating low back pain on the basis of direct nerve irritation, produced by narrowing of lumbar foramina, in turn permitted by partial disc collapse. He stressed the importance of superimposed inflammatory reaction. Whatever may be the mechanism involved, low back pain and distributed pain along the sciatic nerves seems too frequently to be associated with regional skeletal and disc faults to be explained as a casual relationship.

Table II

DISTRIBUTION OF LUMBOSACRAL ANOMALY TYPES OBSERVED IN PATIENTS WITH LOW BACK PAIN AND SCIATIC RADIATION

	Sole Anomaly	Combined with Other Anomalies	Total Occurrence
Sacralization	4.1 %	2.6 %	6.7%
Lumbarization	2.2 %	.8 %	3.0%
Butterfly transverse process	1.3 %	1.2 %	2.5%
Spina bifida	7.8 %	3.0 %	10.8%
Miscellaneous	7.15%	1.55%	8.7%*

* Spondylolisthesis comprises 8.1 per cent, all others 0.6 per cent.

In Table II, the incidence of various well-recognized types of developmental vertebral anomaly are shown. Multiple anomalies are not infrequent. Available figures describing the observed occurrence of the various types show wide variations, as pointed out by Giles.[2] His own figure for spina bifida is considerably higher than ours. We find this difficult to explain for he has carefully recorded location and extent of observed defects. It is probable that the discrepancy in the reported incidence of developmental anomalies of the lumbosacral spine can in a large measure be explained on the assumption that few observers employ identical criteria. We are content to draw attention to a very pointed discrepancy in the incidence of such anomalies between the two case groups studied when the criteria of developmental fault, as well as the quality of the roentgenograms from which observations were drawn, were as nearly identical as we could make them.

Table III serves to show that generalized osteoarthritis of the spine is not responsible for the symptoms in any considerable portion of our cases; that sacroiliac arthritis is even less potent as a causative factor.

Table III

DISTRIBUTION OF OSTEOARTHRITIC CHANGES OBSERVED IN PATIENTS WITH LOW BACK PAIN AND SCIATIC RADIATION

Generalized	8.5%
Localized, involving:	
Sacroiliac joints	4.7%
Lumbar spine only	10.5%

CONCLUSIONS

Narrow lumbosacral joint space is more common in patients with low back pain radiating along the sciatic nerves than in patients without this symptom-complex. Ratio 4.5:1.

Developmental anomalies of the lumbosacral spine are likewise more common in this type of patient. Ratio 2:1.

Osteoarthritis of the lumbosacral spine is no more common in this type of patient than in a control group without the feature of radiating sciatic pain.

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DISCUSSION OF PAPERS BY DRS. BADGLEY AND HODGES AND PECK

Dr. Theodore A. Willis, Cleveland, Ohio. I notice that we orthopedists like to ride

hobbies, especially in regard to backache and various anomalies of the back. My own hobby is the separate neural arch. We have been very fortunate in hearing Dr. Badgley debunk these hobbies of ours. In other words, he showed they exist just as frequently in the spines of the controls as they do in those with backache.

I like to divide the anomalies of the lumbosacral area into two types. First, those that have to do with numerical variation of the spinal segments. These are found in all vertebrate animals, and in man we find fewer of them, or a less degree of variation, than in the other species of animals. In going over several hundred spines and noting these variations, I found that 10 per cent of human spinal columns showed a definite tendency to sacralization of the last lumbar vertebra, and 10 per cent showed a definite tendency toward lumbarization of the first sacral segment. So we have 20 per cent of skeletons showing definite tendencies toward anomalies of this sort.

These anomalies consist of partial or complete sacralization or lumbarization of the transverse processes, and change in the planes of the lumbosacral articulation from the anteroposterior plane to the lateral.

Then we have the other type of variation which we can speak of as evolutionary, perhaps, because we find it only in the human spinal column, and it apparently is associated with the upright posture of man. That is the defective development of the neural arch of the last lumbar vertebra, which appears in 6 or 7 per cent of skeletons giving us a total of 26 per cent. Dr. Badgley's and Dr. Hodges' backache specimens showed within 1 per cent of the normal incidence. So they cannot have a great deal to do with backache.

It is very easy, of course, to have a roentgenogram taken and to point out one of these anomalies and say, "There is the cause of your backache. We will do something about that." But so often we are disappointed in the result of that something that we do.

As regards narrowing of the lumbosacral intervertebral space, Dr. Hodges finds it in 57 per cent of backache patients. That is way above the incidence in the normal spine. The subjects that I examined were skeletons. We measured the discs and the vertebral bodies in a large number of skeletons before they were macerated, and found the average thickness of the lumbosacral disc to be 14 mm. and the average thickness of the fourth lumbar disc 7 mm. So when Dr. Hodges limits himself in speaking of the narrowing of this disc to those which show less than half the width of the one above he is very conservative. He can safely include any normal fifth lumbar disc that is narrower than the fourth, because in the general run of spinal columns that disc is wider than the fourth lumbar. So I say he is very conservative and on the safe side. Yet he finds the intervertebral disc at the lumbosacral junction to be definitely narrower than the discs immediately above in 57 per cent of the columns that show backache, and especially those that show neurological changes. That seems to me an important observation, and we should like to know why this disc narrows. It is probably because of the great strain upon the sacrolumbar disc.

The authors find more arthritis, if there is any difference, in the controls than in the patients with backache. I checked the hypertrophic changes on 600 or 700 lumbosacral joints and found an abnormal incidence in the normal run of dissecting room material greater than they find in the normal spine and definitely higher than in the painful spines. So it seems that arthritis cannot be associated very definitely with backache unless there is some acute condition there.

These papers show how often we must be mistaken in attributing backache to these various anomalies that the roentgen ray shows and to a slight degree of lipping which we find in the roentgenograms.

Dr. Charles L. Martin, Dallas, Texas. This subject is very interesting to me because I have been working for some time with Dr. Paul Williams, a disciple of the Michigan School of Orthopedics. He believes that low back pain is, in most instances, due to changes in the lower spine which can be demonstrated by roentgenological methods. Apparently Dr. Badgley and his coworkers do not concur in this belief. I would like to ask him whether he uses braces and fusion operations in treatment, and if so, how he explains their rationale, if we are to assume that the pain has no mechanical origin. I also hope that in closing he will be a little more specific in his explanations of the cause of pain.

Narrowed spaces between vertebral bodies in medicolegal cases claiming disability following injury have occasioned me no little con-

cern. Will Dr. Badgley please state whether or not he thinks such changes can be caused by trauma and be instrumental in the causation of low back pain?

Dr. Badgley (closing). I wish to thank the discussants of this paper for their definite contribution to it.

In regard to Dr. Martin's inquiry, we believe our studies have consistently shown the frequency in which narrowing of the lumbosacral joint space occurs in this disease entity. Williams' conception that the radiation of pain into the leg is due to mechanical alteration of the size of the intervertebral foramen with irritation direct or indirect on the fourth or fifth lumbar nerve root was first suggested by Danforth and Wilson and later substantiated by Putti.

Our contention in this paper is that this conception of mechanical irritation of the nerve roots in the intervertebral foramen may be true in a certain group of this clinical entity, but is not true for the entire group. Inasmuch as the symptomatology is the same for the entire group, this theory cannot be considered adaptable for the entire series of cases. The following facts mitigate against this theory: (1) Inasmuch as the fourth and fifth lumbar nerve roots also supply the tibial nerve as well as the peroneal distribution of the sciatic it would be reasonable to anticipate an occasional tibial nerve radiation in this group, but in our entire series we have not seen a single case with such involvement. (2) The sensory distribution of the fourth and fifth lumbar nerve roots is still uncertain. The variety of anatomical charts with different areas credited as supplied by these roots is evidence of that. (3) Anatomically, the fourth and fifth lumbar nerve roots are not components of the sensory nerves above the knee, so that it is difficult to credit these nerve roots with the radiation of pain in the buttock or thigh. (4) We know that in lesions such as tuberculosis of the first lumbar body of the intervertebral type, and in cases of tuberculosis of the sacroiliac joint, this same symptom-complex of low back pain with radiation along the typical pathway frequently occurs, yet there is no evidence in these lesions to credit the fourth or fifth lumbar nerve roots for the radiation of pain. (5) One hundred ninety-one of the 447 cases reported in this series have this same symptomatology with no evidence of narrowing of the fourth or fifth lumbar intervertebral spaces. It is difficult in this group to blame mechanical irritation of the fourth and fifth lumbar nerve roots as a causative factor for the symptomatology.

The mechanical conception for the pathogenesis of sciatic pain is not applicable for the entire group of cases with their symptom-complex. Is there any explanation which will fit all cases?

In a previous paper, we presented a theory based upon the definitely known origin of the sensory nerves of the lower extremity and the embryological development of the lower extremity. The characteristic pathway of the radiation of pain occupies the fetal dorsal axial surface of the extremity and the radiation of pain is distributed by the sensory nerves which arise from the postaxial portion of the lumbosacral plexus.

It is our contention that the radiation of pain is not due to direct or indirect irritation of the fourth or fifth nerve roots necessarily, although this may be the chief factor in a number of cases. We feel that the pain is radiated primarily by a reflex mechanism from irritation to the sensory nerve endings either in the soft tissues of the low back or to the capsular structures of the articular facets or intervertebral articulations and centrally from the involved area to be radiated through the postaxial plexus of the lumbosacral joint to the postaxial surface of the lower extremity.

This theory in no way refutes the importance of the narrowed lumbosacral joint in this syndrome, but neither does it require localization of the causative factor for this syndrome to this area. Any part of the lumbar spine, the lumbosacral joint or the sacroiliac joint, or the soft tissues of the low back may be the seat of the underlying pathology producing this syndrome. Each case is a problem in itself and requires individual study.

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VISUALIZATION OF SALIVARY GLANDS FOLLOWING USE OF OPAQUE MATERIAL IN THE MOUTH*

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OPAQUE material such as preparations of iodine (lipiodol) and bromine have often been used in late years as a means of visualizing the salivary ducts on roentgenograms by injection directly into the opening of the duct in the oral cavity, but visualization, without injection, by foreign material left within the mouth seems not to have happened. A search through the articles listed in the *Index Medicus* failed to reveal a single case in which the glands or their ducts have become visible following the use of radiopaque substances free in the oral cavity. A case in which two salivary glands became visible on roentgenograms in this way is therefore of more than casual interest.

CASE REPORT

D. C. C., a white female, aged eighty-four, came to the hospital for a roentgen examination of the right clavicle which had been fractured several months previously in an automobile accident. A large film was used to secure similar views of both shoulders. The finished roentgenogram showed two elliptical shadows of increased density near the lower margins of the mandible. Attention was immediately directed to the cause of these shadows. Salivary calculi were first considered, but could be readily ruled out. The patient and her physician revealed that the gums adjacent to the partially exposed roots of the few remaining teeth had been sore and very annoying. The patient had become dissatisfied with the treatments given by her dentist and consequently had supplemented these with treatments of her own. These consisted principally of remedies found at home. The patient states that she "tried everything" to get relief. Not all of the things applied to the gums are known, but certain styptics are known to have been used either by the patient or by her dentist. After several weeks of self-prescribed medication, it was noted that the secretion of the mouth became scant and sticky. This condition was still present at the time the examination mentioned above showed the two spindle-shaped shadows on the roentgenogram. The treatments were discontinued, and two months later an additional roentgenogram revealed that these shadows (Fig. 2) had completely disappeared. However, the amount of saliva continued to be somewhat inadequate for approximately five weeks. The lingual or submaxillary glands were not tender or noticeably enlarged at any time and the patient had no pain relative to the glands. The saliva has been ample in amount and the patient has had no complaint for a period of eighteen months since discontinuing the treatment.

COMMENT

Recorded cases in which the salivary ducts have been visualized by the injection of opaque material have shown a somewhat different roentgen appearance than this case. The shadows have been homogeneous and have had smooth but somewhat irregular contours, as though due to dilatation of the ducts by pressure. None of the opaque material seemed to have entered the gland itself. In published illustrations there has been an oblong shadow measuring approximately 3×1.5 cm. on the duct side of the gland. This shadow has presented a wavy, smooth upper border and a more regular lower border adjacent to the gland. In the present case, each composite shadow (Fig. 1) is divided into tiny islands of relative increased density suggesting the structure of the gland itself. This variation from previously reported cases raises the question as to the exact location of the opaque material. The symmetry of contour of each individual com-

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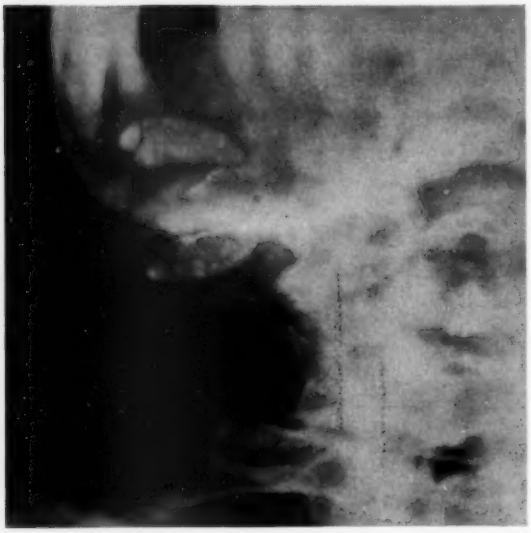

Fig. 1. Two elliptical shadows which are apparently due to opaque material within the substance of the gland. Note that the pattern of each composite shadow is exactly like the other. Note also the thin dense line indicating the duct. These changes followed the prolonged use of certain substances in the mouth.

posite shadow and pattern of densities which make up each of these, as well as the absence of enlargement of the glands on palpation, favor the presence of a small amount of foreign material within the acini of the glands, rather than in the larger ducts as seen following the injection method of visualization. This peculiar roentgen shadow has not been present in any reported case and possibly is due to the inherent nature of the material used and its frequent and prolonged presence in the mouth. The mirror-like resemblance of one composite shadow to the other is striking. This perfect duplication of shadows would not be expected were the shadows produced by opaque material in any place but the gland substance. The main ducts which are visualized on the film as a thin, dense, white, irregular line further support the contention that the gland is visualized. If a stenosis of otherwise normal ducts existed, their lumina would be larger and their contour smoother, and if the effect were produced solely by inflammation or by the astringent action within the mouth, the secretion of saliva should have become normal in amount within a few days after the soreness had disappeared. It is noteworthy that the symptoms improved almost immediately after stopping the treatment but that the amount of saliva was not entirely satisfactory for more than a month. The loss of function that occurred here seems to be due principally to the action of the chemical substances directly upon the gland. Because of the effective material being opaque to the roentgen ray, its presence was recorded on the roentgenogram. Complete clearing later (Fig. 2) with return of function, suggests that the glands received little, if any, permanent injury, although they had been practically functionless for weeks.

It is regrettable that the exact chemical substances or combination of materials producing this unusual result are not known. The active substances most commonly used in styptic pencils and astringents in the treatment of the gums and which seem likely to have been used in this case are: ferric chloride, zinc chloride, silver nitrate, aluminum potassium sulphate (alum), potassium permanganate, and tincture of iodine. It is conceivable

Fig. 2. Same patient two months after discontinuing treatments. The shadows have disappeared. Saliva at this time is ample in amount and apparently normal.

that any one of the first three and the last, in high concentration, might produce the shadows. Silver nitrate seems to have been used more often and over a longer period of time than any of the others. Argyria has not been in evidence.

The cause of the spontaneous backflow of a certain substance to the gland from the oral cavity in this case is not known. It is possible that fluids in the mouth normally reach the salivary glands at times. That such retrograde action may take place, that it can be brought about by foreign material left within the mouth, and that under certain circumstances it is thus possible to visualize the material within the salivary glands themselves, are the important points illustrated by this case.

DIAPHRAGMATIC HERNIA*

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A REPORT is presented of 6 cases of diaphragmatic hernia diagnosed roentgenographically, with special reference to the variability of the clinical manifestations and to the erroneous diagnoses made before roentgen examination.

Diaphragmatic herniae are simply protrusions of one or more of the abdominal viscera into the thoracic cavity through a congenital or acquired opening.

Riverius, as early as 1698, reported a case of congenital diaphragmatic hernia. This condition, however, has been known chiefly since Louis Petit's first cases were reported by his student Lesne in 1774.

DIAGNOSIS

Arnsperger states that prior to 1908 the condition of diaphragmatic hernia had not been recognized during life in more than 10 instances. The diagnosis of herniation of the diaphragm is often difficult without the aid of roentgenologic examination. It is still more difficult if the patient is symptom-free and if there are no signs that suggest any abnormality in the chest wall.

On the other hand, it may be provocative of distressing and other grave symptoms of a respiratory, gastric or intestinal nature. It is only in the supine or Trendelenburg position that many of these herniations are demonstrated roentgenographically and too often these positions are neglected in roentgen examination of the gastrointestinal tract. The importance of recognizing this type of lesion needs emphasis because of the variability of the symptoms which the patient may present. Some patients may complain of difficulty in breathing, others of typical anginal attacks where the pain is referred to the left arm and left shoulder, and in still others, the symptom may be only a sense of discomfort referred to the epigastric or retrosternal region. This type of epigastric discomfort is seen very frequently in pregnancy where the intra-abdominal pressure has caused a relaxation of the esophageal hiatus, permitting a portion of the stomach to herniate through it. It is of practical importance to determine whether in a case of herniation through the esophageal orifice there is a normal or a short esophagus. The presence of the latter contraindicates surgery. Diaphragmatic hernia is to be regarded as congenital until proved traumatic.

CLASSIFICATION AND PATHOGENESIS

A modification of LeWald's classification of certain congenital and acquired conditions of the diaphragm.

1. *Absence of the Left Half of the Diaphragm.* Diagnosis can be made roentgenographically, especially in the lateral position. It is important in this type to determine from the roentgen examination the contents of the left half of the chest. This information is needed in case of the occurrence of some inflammatory lesion in the displaced viscera in this area.

2. *Thoracic Stomach.* In this condition the diaphragm is perfect in form and is intact on both sides, but the stomach is entirely within the chest cavity. The esophagus is very short and the duodenum, or in some cases the pyloric end of the stomach, passes through the opening in the diaphragm which would ordinarily accommodate the esophagus.

3. *Eventration of the Diaphragm.* This condition usually occurs on the left side but occasionally on the right. It may occur on both sides. It is usually associated with megalocolon. The diaphragm may be as high as the second costal cartilage, perfectly regular, with no defect in outline. The complete outline of the diaphragm,

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especially on lateral exposures, can be visualized no matter how high. It is also possible to visualize the diaphragm in the posteroanterior view. This condition is due to the lack of proper musculature. The term (eventration) was applied by Petit in 1790 to the condition of chronic idiopathic, unilateral elevation of the diaphragm. This may be a cause for paradoxical movements of the diaphragm.

4. *Congenital Hernia.* This is a defect in the diaphragm at birth allowing abdominal contents to pass into the chest cavity. According to Lupman 87 per cent of this type are false in that they pass directly through a congenital or through a dilated normal opening without a sac. The true type occurs in 13 per cent of the cases and has a definite sac. Congenital hernia occurs usually on the left although it may be present on the right. Roentgen examination in all positions and at different times will demonstrate that at one time a portion of the stomach is above the diaphragm and at other times below. Likewise, a portion of the colon may be above and at another time below. There is not likely to be this extreme variation in the condition of complete absence of the left half of the diaphragm, from which congenital hernia is to be differentiated.

5. *Acquired Hernia.* This may occur through the esophageal orifice due to a gradual relaxation of this opening. The patient should be examined in the horizontal and Trendelenburg positions. It is sometimes necessary to have the patient cough or strain in order to force the cardiac end of the stomach into the chest alongside of the esophagus. Occasionally this condition may be suspected by the absence of the usual gas bubble at the cardiac end of the stomach, especially if cardiospasm is ruled out. Occasionally a loop of colon may use this means of getting into the chest.

CASE REPORTS

Case 1. M. M., male, aged twenty-one.

Previous History. No history of trauma. Left-sided "pleurisy" four years ago. Otherwise well until three years ago when he began to suffer from "gas pains."

Fig. 1. Case 1. Chest roentgenogram before the gastrointestinal series.

Present History. Comes to the Gastrointestinal Clinic complaining of severe sharp pain throughout the abdomen one and a half hours after eating.

Physical Examination. Essentially negative except for tenderness over the epigastrium.

Clinical Diagnosis. Possible gastric ulcer.

Roentgen Examination. Chest: Lungs—Obliteration of the normal lung markings in the lower portion of the left lung and replacement by concentric shadows containing air and fluid, suggesting the presence of intestinal contents. The upper portion of the left lung showed normal illumination. Diaphragms: The inner half of the left diaphragm is defective, while the outer half is elevated and fixed. The right diaphragm is normal. Costophrenic angles: The left is obliterated while the right is normal. Heart: Normal in size, shape; displaced slightly toward the right. Trachea: Not deviated.

Gastrointestinal series. Esophagus: Normal in size, shape and position. Stomach: Ptosed,

Fig. 2. Case I. Roentgenogram after barium enema with the patient in the Trendelenburg position.

dilated and displaced into the right lower quadrant. Rugae normal. Peristalsis sluggish. The stomach assumed variable positions, rotating from left to right during the various examinations. Duodenum: Cap is large, not tender and assumed variable positions, rotating with the stomach. Second and third portions

Fig. 3. Case II. Rugae of the cardiac end of the stomach seen herniating through the esophageal orifice above the diaphragm.

normal. Colon: There is a defect in the inner portion of the left diaphragm with herniation of the ileocecal region, cecum, ascending colon and all but the two distal inches of the transverse colon into the left chest cavity with the contents reaching the level of the first costal cartilage in the recumbent position.

Conclusion. Left congenital diaphragmatic hernia.

Case II. J. I., male, aged fifty-four.

Previous History. Essentially negative. No history of trauma.

Present History. Complains of belching and

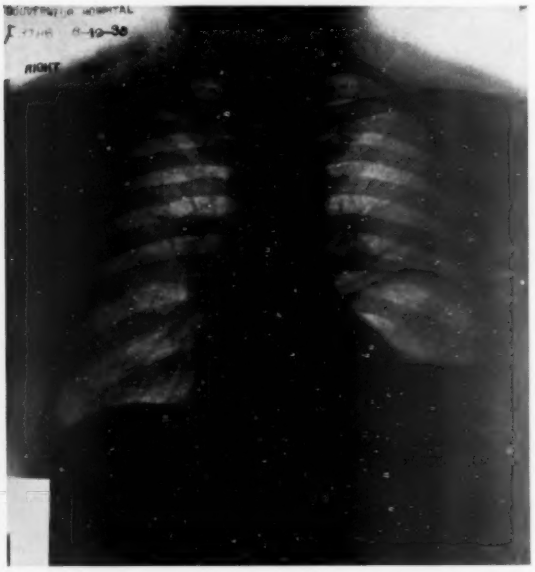

Fig. 4. Case III. Roentgenogram of barium filled stomach with the patient in the upright position.

vomiting attacks of several weeks' duration. Loss of about 10 pounds during this time.

Physical Examination. Negative.

Clinical Diagnosis. Possible carcinoma of the stomach.

Roentgen Examination. Chest: Heart—Normal in size, shape and position. Lungs—No variation from the normal. Diaphragms: Normal in relation to each other, no defects noted. Costophrenic angles and trachea were normal.

Gastrointestinal series. Esophagus: Slightly dilated in its lower end but regular in outline. Stomach: There is a herniation of the cardiac end of the stomach into the esophageal orifice, especially demonstrable in the Trendelenburg position. The stomach is otherwise normal in size and shape. Rugae normal and peristalsis

active. Duodenum: Cap and the second and third portions normal.

Conclusion. Diaphragmatic herniation of the stomach through the esophageal orifice.

Case III. R. G., male, aged sixty-five.

Previous History. Essentially negative. No history of trauma.

Present History. Complains of cough and dyspnea of several years' duration.

Physical Examination. Negative.

Clinical Diagnosis. Undiagnosed.

Roentgen Examination. Chest: Lungs—No variation from the normal. Heart: Normal in size, shape and position. Diaphragms: Normal in position and relation to each other. Costophrenic angles and trachea are normal.

Gastrointestinal series. Esophagus: Normal in size, shape and position. Stomach: In the Trendelenburg position there is visualized a herniation of the upper two-thirds of the stomach into the left chest cavity. This is absent when the patient assumes the erect posture. The stomach was otherwise normal in size and shape. The hernia is through a defect in the left diaphragm.

Conclusion. Diaphragmatic herniation of the stomach through a defect in the left diaphragm.

Case IV. R. B., female, aged thirty.

Previous History. Essentially negative except for two previous normal labors. No history of trauma.

Fig. 5. Case III. Trendelenburg position.

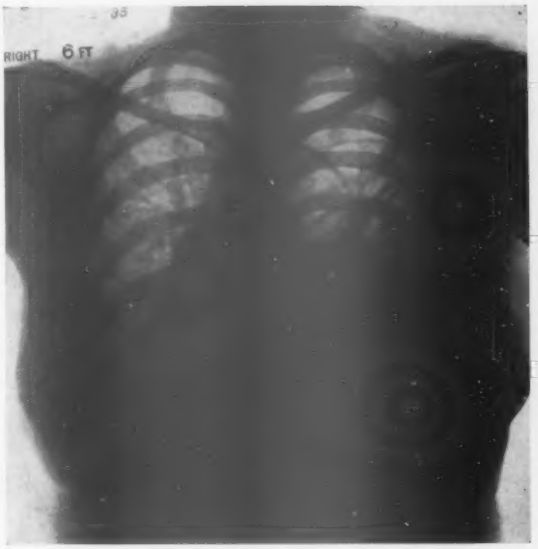

Fig. 6. Case IV. Chest roentgenogram before gastrointestinal series.

Present History. Onset of cough with some expectoration during the eighth month of the third pregnancy.

Physical Examination. Patient shows an eight months pregnancy which appears to be normal. There is, however, absence of breath sounds and tactile fremitus below the fourth rib on the left side. The heart appears to be displaced toward the right. Temperature and pulse normal.

Clinical Impression. Left pleural effusion.

No roentgen study was made until two months later, which was one month after a normal left occipito-anterior labor.

Roentgen Examination. Chest: Lungs—Obliteration of the normal lung markings in the lower two-thirds of the left side and replacement by concentric shadows containing air and fluid suggesting the presence of loops of the colon. The upper portion of the left lung showed normal illumination. Diaphragms: There was a defect in the inner portion of the left diaphragm allowing the herniation. The outer half together with the right diaphragm was normal.

Gastrointestinal series. Esophagus: Normal in size, shape and position. Stomach: Is variable, assuming a normal and at other times an inverted position in the right lower quadrant. Normal in shape but somewhat atonic. Rugae

Fig. 7. Case iv. Roentgenogram showing colon in the chest. Horizontal position.

normal and peristalsis sluggish. Pylorus patent. Duodenum: Cap and the second and third portions normal. Colon: A herniation of the transverse and descending colon is visualized protruding into the left chest cavity reaching the level of the first costal cartilage. Seen in both the horizontal and erect postures.

Conclusion. Diaphragmatic hernia of the colon into the left chest cavity; probably a congenital weakness aggravated by the pregnancies.

Case v. B. L., male, aged forty-six.

Previous History. Essentially negative. No history of trauma.

Present History. Admitted to the hospital for the repair of a right inguinal hernia of seventeen years' duration. He has suffered from occasional cough during the previous few weeks.

Physical Examination. Moist râles throughout both lungs with some diminution in the breath sounds and tactile fremitus in the lower left chest.

Clinical Diagnosis. Chronic bronchitis.

Roentgen Examination. Chest: Lungs—The upper half of the stomach is seen to be displaced into the left chest through a defect in the inner half of the left diaphragm. The lung tissue in this area is displaced upward. The remaining portions of both diaphragms are normal. The heart is only slightly displaced toward the right.

Gastrointestinal series. Esophagus: Normal in size, shape and position. Stomach: The herniation is seen in both the erect and horizontal postures. The stomach is otherwise normal in size and shape. Rugae normal. Peristalsis normal. Pylorus patent. Duodenum: Cap and the second and third portions are normal.

Conclusion. Diaphragmatic herniation of the stomach through a defect in the left diaphragm.

Case vi. A new-born male baby.

Present History. Immediately after an uneventful labor there was a delay in the onset of respiration. Clearing of the mucus in the mouth and pharynx, artificial respiration and the tapping of the soles and buttocks produced only partial clearing of the cyanosis and a weakened cry. The condition remained unchanged until seven hours later when the breathing became very shallow and the cyanosis increased. Artificial aids were not helpful and the patient expired seven and a half hours after birth.

Fig. 8. Case v. Herniation of the stomach. Erect position.

Roentgen Examination. Before death. Revealed a congenital defect in the left half of the diaphragm with the abdominal contents protruding into the left chest and reaching the left apex. No lung markings present on the left side. The heart was normal in size and shape but was displaced toward the right. The left chest cavity was occupied by the stomach, small intestine and practically the entire colon. The right half of the diaphragm was normal.

Autopsy findings and post-mortem injection of the gastrointestinal tract confirmed the above roentgen findings.

Conclusion. Congenital diaphragmatic hernia.

GENERAL CONCLUSIONS

Six cases of diaphragmatic hernia, not recognized clinically until examined roentgenographically, have been presented.

The variability of the clinical manifestations and the consequent erroneous diagnoses of chest and abdominal lesions demonstrate the importance of roentgen examination in all cases where the clinical picture is not adequately explained.

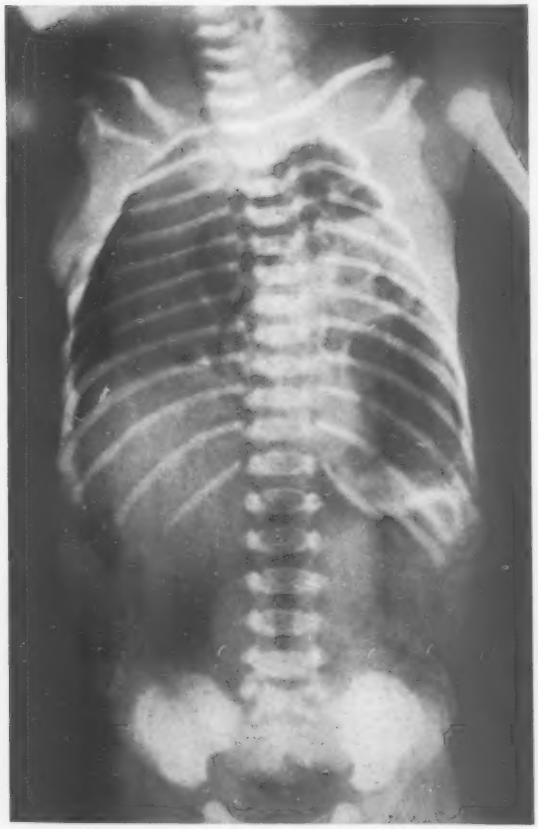

Fig. 9. Case vi. Before death. Abdominal contents in the left chest.

Fig. 10. Case vi. Post-mortem injection of the gastrointestinal tract.

In obscure cases of respiratory, gastric or intestinal diagnoses, the roentgen examination of the gastrointestinal tract and of the chest must be made in the Trendelenburg and horizontal as well as in the erect posture.

It is an aid in suspected cases of diaphragmatic herniation to have the patient cough and strain in the various postures so as to bring out the hernia during the examination.

Finally, we would like to stress the ne-

cessity for the correlation of the complete roentgen examination as well as the physical and clinical examination in order to be able to diagnose the condition of diaphragmatic hernia.

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ROENTGEN ANALYSIS OF 100 CASES OF URETERAL STONE

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THIS study was undertaken because it was felt that calculi were not being demonstrated in a considerable percentage of patients with definite ureteral colic. The reason for this was not clear: that is, whether the stones were non-opaque or whether their shadows were not being recognized. From the literature it is apparent that ureteral calculi are demonstrable on the films in a high percentage of cases (Immelmann, Israel, Ravich, Bumpus and Thompson). The average figure given is 96 per cent. The best results were those of Bumpus and Thompson who were able to visualize the stone in 98 per cent of 1,001 cases. They attributed their high percentage to the fact that the urologist, who was aware of the clinical findings, interpreted the films.

Therefore, we reviewed 100 cases in which the diagnosis had been well established. These cases were taken consecutively from the discharge files of the Hospital for the past two and a half years. In 54 of the patients the stone had been recovered from the urine or removed surgically. For the remaining 46 cases in which the calculus was not actually obtained it was apparent that some criteria would have to be fulfilled before a diagnosis of ureteral stone would be justified. These criteria can be divided into four groups as follows: the history; the urine examination; the cystoscopic, and the roentgenologic findings.

In the history the outstanding symptom was pain. It occurred in every patient and was always on the same side as the calculus. It should be mentioned here that cases have been reported in which the calculus was on the opposite side to that of the pain (Heyderdahl). Such a condition must be considered quite unusual.

Examination of the urine showed hematuria, either grossly or microscopically in 79 of the patients. Therefore, the presence of blood in the urine was considered as very good evidence in favor of ureteral stone. Since 19 cases did not have hematuria, however, the absence of red blood cells in the urine was not a serious objection to a positive diagnosis.

The important cystoscopic findings were: first, a reddened edematous ureteral orifice; second, obstruction or grating to the catheter; third, a hydronephrotic drip of urine with relief of pain after the catheter passed the obstruction. At least one of these was present in nearly every case and not infrequently all three were found in the same patient.

The roentgenologic findings can be divided into three groups. In the first group are those cases in which the calculus produces a shadow on the film which, after the ureter is demonstrated, is seen to lie within its course. In the second group are the secondary signs consisting of a poorly or non-functioning kidney as shown by intravenous pyelography; and also the presence of hydronephrosis demonstrated either by the intravenous or retrograde routes. Either reduced renal function or some degree of hydronephrosis was present in 78 of the cases. A few cases showed neither of these findings. The third group includes the cases of non-opaque stones in which a filling defect is seen in the dye-filled ureter. This was observed only once.

Of the above described findings a sufficient number were present in all our cases to establish the diagnosis. However, of the original 100 roentgen reports, 21 gave no indication that any shadows were present which might be interpreted as calculi. The films of these patients were then carefully

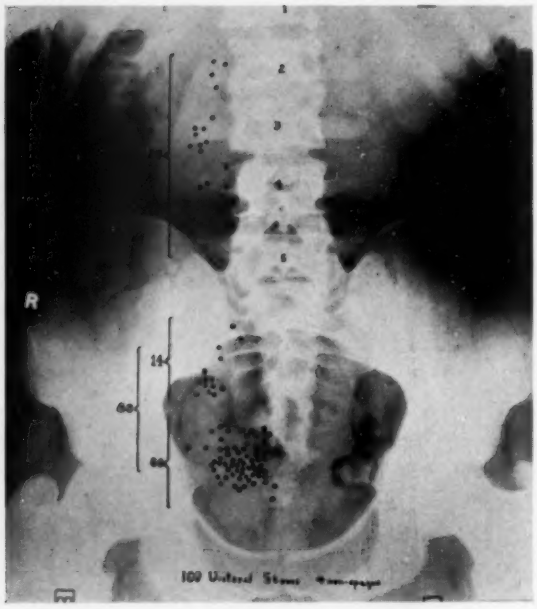

Fig. 1. This illustration shows the location of the 100 calculi. All the stones have been dotted in on the right side emphasizing the large percentage in the lower ureter.

restudied with a knowledge of the clinical data in each case. Shadows which unquestionably represented the calculi were seen in 17 of the 21 cases, previously reported as negative. Thus the roentgenograms now confirmed the diagnosis of ureteral stone in 96 per cent of the patients, agreeing with the figures found in the literature.

All the films were then reëxamined with particular reference to the size and location of the calculi. The position of the stones was reconstructed on a large film of the urinary tract, as is shown in Figure 1. Each dot represents a single case and the position of the stone on the original film was reproduced as closely as possible in relation to corresponding parts of the bony skeleton. The probable position of the four non-opaque stones was estimated from the cystoscopic reports and they are shown as circles. In Figure 1, the stones have all been placed on the right side and no size distinction made. In Figure 2, the exact location with respect to right and left side is shown and those stones measuring over 5 mm. on the original film are depicted by large dots whereas those measuring less than 5 mm. are represented by small dots. These diagrams show clearly that 80 per cent of the stones are located in the pelvis and that 66 per cent are in the extreme lower end of the ureter. Only 20 per cent are situated in the lumbar portion of the ureter and these measure 5 mm. or more. Closer examination of the stones forming the 66 per cent in the lower ureters reveals that they lie above a line joining the extreme bases of the ischial spines. Anatomically this line corresponds approximately with the lowest level of the intramural section of the ureter (Fig. 3). The one large stone shown below this line was situated in a ureterocele prolapsed into the bladder. The probable explanation for the high percentage of stones in this location is that the intramural section of the ureter is more rigid and less easily dilated. Consequently, the passage of a calculus through the ureter will be delayed here.

On the roentgenogram this region is always found above the line shown in Figure

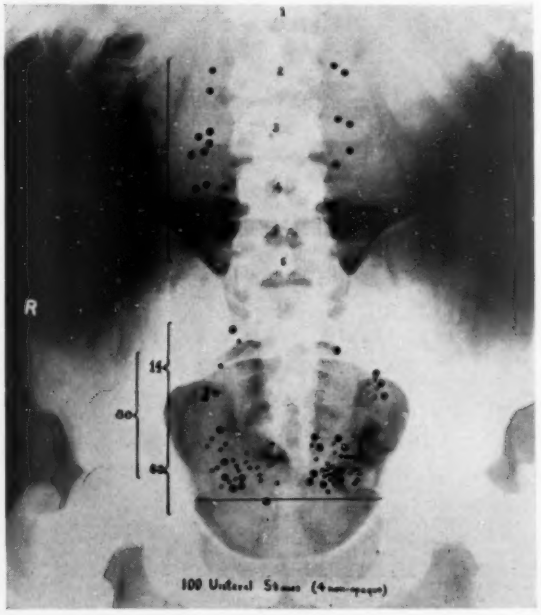

Fig. 2. Exact location as to right and left sides shown. Stones measuring over 5 mm. are represented as large dots. Note the line joining the lowest part of the ischial spine and the calculi lying above it.

2 and includes the circular area measuring about 4 cm. in diameter situated just medial to the ischial spines. The more medially a stone is located, the more it tends to approximate this line. Conversely, any shadow on or below this line but near the ischial spine is not likely to be within the ureter. It is possible, however, for a ureteral stone to lie lateral to but above the ischial spine. As previously mentioned 66 of the 100 stones were found in this small area and, in addition, all calculi under 5 mm. in diameter are included in this group.

For this reason it was not surprising to discover that 16 of the 17 calculi not diagnosed on the initial interpretations were very small and situated in this region. Slides or prints illustrating these cases were extremely difficult to reproduce due to the small size of the stones (Fig. 4).

Referring again to Figure 2, it is seen that the stones located in the lumbar division of the ureter are all large and therefore easily and distinctly visible on the film. We believe small calculi are not found here because the ureter readily dilates, permitting them to pass down to the bladder before the patient is examined. Films taken as early as three hours after the onset of pain have shown this to be the case. Only a very few calculi were found projected onto the sacrum or ilium and in each case they were correctly interpreted.

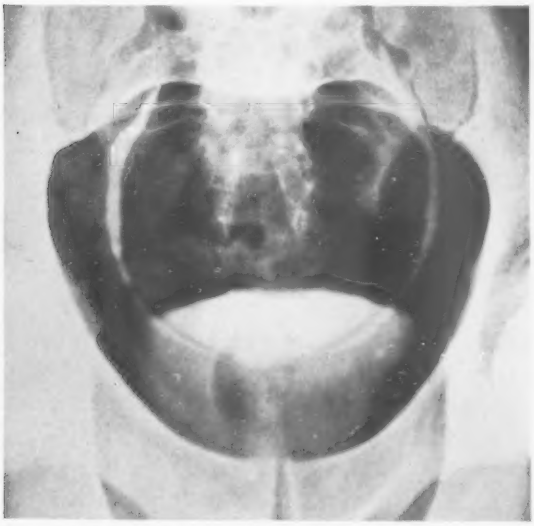

Fig. 3. Normal relationship of the lower end of the ureters to the bladder and ischial spines.

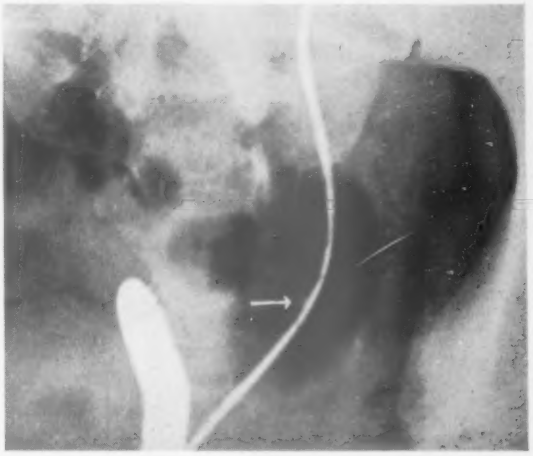

Fig. 4. Small calculus in the lower end of the ureter. This is the type which is overlooked by the roentgenologist.

An interesting association was discovered on correlating the history with the size and location of the calculi. All the patients with large calculi in the lower end of the ureter had urinary symptoms of long standing. Thus the roentgenologist may predict on seeing a large stone in the lower ureter that the patient has been ill for some time and that the present attack of ureteral colic is not the initial one. Likewise, a small calculus in this location usually means an acute attack of a few hours to a few days in duration.

As regards technique, a single large film of the urinary tract with the tube centered at the level of the iliac crests was found to be the most desirable. If the kidney and bladder regions are taken separately it is important that the film of the pelvis is not taken in the usual manner, that is, centered directly over the pelvis. Instead, the tube should again be centered about the level of the iliac crests and angulated towards the feet so that the central ray is projected along the pelvic axis. If the tube is centered directly over or below the pelvic inlet the resulting roentgenogram will show a flattened bony pelvis in which the ischial

spines may be projected on the same level with or below the upper margin of the superior ramus of the pubis. Such a picture might be confusing because the lower end of the ureters lie at approximately this same level and hence a stone in this region may be projected onto or very near the pubic bones, especially if the bladder is contracted.

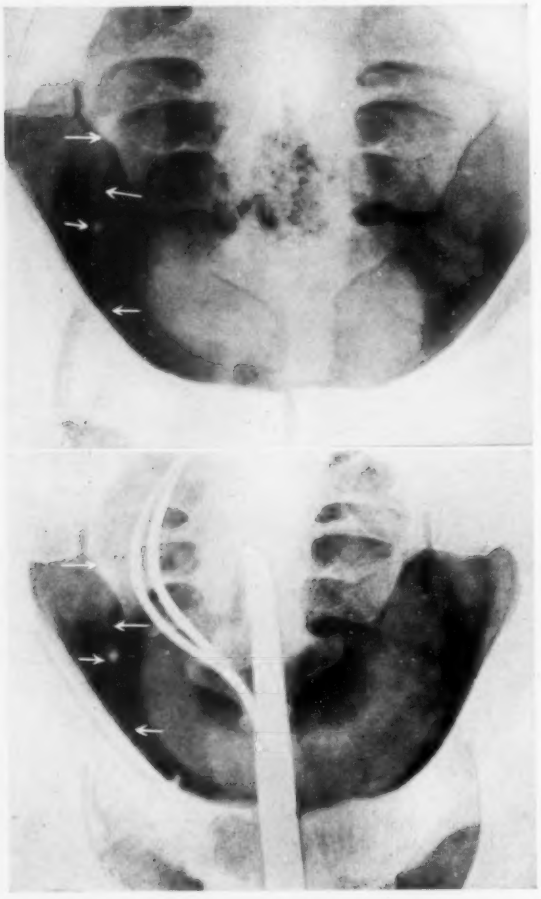

Fig. 5. Linear soft tissue shadow containing a phlebolith resembling dye-filled ureter with a calculus. There is also a double ureter.

If has frequently been observed that a concretion outside of the ureter can be projected onto the shadow of the ureter. In 1918, Kretschmer introduced the double exposure film for eliminating this source of error. It consists of making one exposure and then shifting the tube a distance of 6 to 8 cm. and making a second exposure. An object which is not closely associated with the ureter will now be separated from the ureteral catheter on one of the views. Both exposures can be made on one film but the resulting picture is not as clear as when two films are used. Another remote, but possible, cause of error in diagnosis is the presence of a double ureter in which the catheter has been inserted into the one which does not contain the stone. Careful cystoscopy in which a search for the other orifice is made, or the use of intravenous pyelography will usually establish the presence of this anomaly.

No studies were made concerning the chemistry of the calculi and its relation to the roentgen pictures. However, the shadows produced on the roentgen films were usually of a homogeneous density with irregular outlines. The majority of small stones cast shadows which are slightly less dense than phleboliths and are composed of calcium urates and triple phosphates. Calcium oxalate stones occur less frequently and are very dense (Heyderdahl). Nonopaque stones are composed of cystine, xanthine or uric acid with extremely little or no calcium content. This type of stone comprises only 4 per cent of this series.

There are a large number of shadows described which can be mistaken for ureteral stones. The ones most frequently seen are phleboliths, fecal material, calcification in the pelvic arteries and calcified abdominal glands. Usually these shadows cause no further difficulty after the course of the ureters has been demonstrated. However, on the plain films they can frequently be ruled out. If the shadow is not on the same side as the pain, in all probability it is not a stone. Small phleboliths are usually round with a central area of decreased density. Large phleboliths are not uniformly dense, but have irregular areas of rarefaction within them. An interesting shadow of diagnostic importance has been seen in the true pelvis on plain films of several patients. This shadow resembles in every respect a ureter filled with dilute dye. Instead of curving medially to the ureteral orifice,

however, it usually descends towards the pubis. Frequently, we have seen small rounded dense shadows lying along its course and we have come to regard this relationship as pathognomonic of phleboliths. Although we do not know what produces this shadow, its frequent association with phleboliths strongly suggests that it is of vascular origin (Fig. 5). A ureteral stone has never been observed to lie within its course. Fecal material may occasionally produce areas of increased density which are confusing. Films taken following a cleansing enema will show these areas to have disappeared. Calcifications in the pelvic arteries are most frequently seen just below the sacroiliac joints, are generally bilateral, and as a rule are not limited to a single area. In fact, it is often possible to trace the vessels in either direction from the shadow in question. Calcified abdominal glands are usually seen as a cluster of small dense nodules which on repeated films may have shifted so that they no longer lie in the course of the ureter. After the course of the ureters has been shown by roentgenography with catheters in place or intravenous urography the majority of the above-mentioned shadows can be disregarded.

Seventy-two of our cases were in males, and 71 were between the ages of twenty and fifty years. This is in agreement with the much larger series of cases reported by Jeanbrau, Grossmann, Bumpus and Thompson, and Ravich. We had no case under ten years of age but Rafin and von Bókay have reported two large series of ureteral calculi in infants and children.

SUMMARY

In summary, we may say that 96 per cent of the ureteral stones in this group of 100 cases were visible on the roentgenograms. The stones most frequently overlooked by the roentgenologist are small and are situated in the lower end of the ureter. The relatively small area medial to the spine of the ischium and just above a line joining the lowest part of the ischial spines should be carefully examined in every case suspected of having a ureteral calculus. Any shadow in this area having the characteristics of a ureteral stone and not obviously a phlebolith warrants further investigation if the patient's symptoms are referred to this side.

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DISCOGENETIC DISEASE OF THE CERVICAL SPINE WITH SEGMENTAL NEURITIS

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BEIRUT, LEBANON, SYRIA

I

THIS study has its origin in the dissatisfaction experienced during the last five or six years in the course of roentgen examinations of patients suffering from pain in the shoulder girdle. No doubt many other physicians also have had the experience that roentgenograms of the shoulders, in these cases, give little information as to the cause of the discomfort. In such circumstances, an internist is often inclined to connect the symptoms with aortic or cardiac disease in the case of the left shoulder, or with hepatic pathology in the case of the right. The one or the other of these suspicions may seem to find some roentgenological support in the presence of a noticeably dense aortic shadow, or in the recognition, for example, of a gallstone. The long duration and persistence of the pain, however, together with progressive weakening of some more or less clearly defined group of muscles is scarcely compatible with the notion of referred symptoms radiated from these regions. In fact, it was, in 2 cases, the conspicuous unilateral atrophy of the deltoid which suggested segmental neuritis as the localized lesion accounting for the condition described. This finding suggested the cervical spine as the seat of the lesion. The clinical results of investigations of over 50 cases have recently been published.[15] It is the purpose of this paper to describe the roentgen findings and to discuss the position of this group of cases in the classification of spinal lesions.

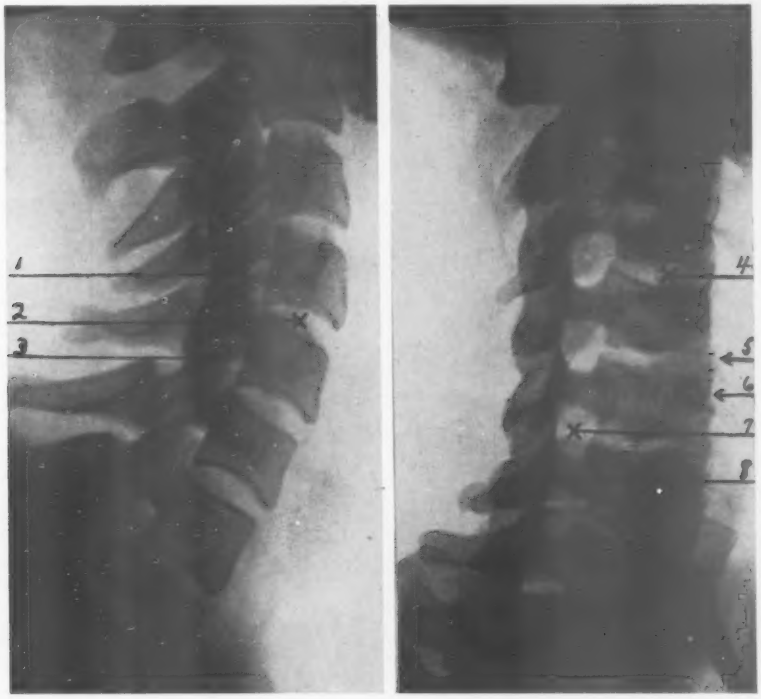
The most evident changes commonly observed in roentgenograms of the spine consist of those exostotic deformations of the vertebral bodies which are characteristic of hypertrophic (deforming) spondylitis (spondylosis deformans (Schmorl)). Nachlas,[11] in 1934, and Hanflig,[9] in a recent publication (1936), have described this type of roentgen findings as arthritic changes which they observed in patients presenting symptoms of brachial neuritis. At the beginning of our investigations, we were inclined to correlate the clinical symptoms of segmental neuritis with hypertrophic cervical deformities similar to those often found in lower spinal segments. This conception, however, does not cover all of the facts observed. Lipping and exostoses, the findings typical of deforming spondylitis, are noted in general at the anterior and lateral borders of the vertebral bodies only. It is difficult to see how such changes would account for damage to nerve roots, the latter being located in the posterior part of the vertebra, namely the intervertebral foramen, which, in deforming spondylitis, is usually found free of arthritic deformities both roentgenologically and post mortem. To avoid this discrepancy, an inflammatory reaction around the nerve roots has been assumed by some authors. This assumption is based on comparatively few operative and autopsy findings in which actual inflammation of soft tissues around the spinal cord or nerve roots was present. In all of these cases deformations of vertebrae had been found roentgenologically. Infectious arthritis, therefore, has been considered responsible for the disease. Nathan[12] was able to demonstrate experimentally on dogs that injection of hemolytic streptococci was followed, in some instances, by inflammatory swelling of spinal joints. Clinically, inflammatory spondylarthritis following acute or chronic infections and, associated with nervous

lesions, has been known since Bechterew's famous report was published. In patients of this group, a history of acute or subacute polyarthritis is in general mentioned by the authors.

In our cases, the histories did not reveal recent or remote infectious arthritis. Moreover, our material includes a number of observations in which no hypertrophic deformities at all could be found in spite of the clinical symptoms which were fully developed.

Regardless, however, of the presence or absence of hypertrophic excrescences, one finding in this group of cases is constant: it is the definite narrowing of one or more intervertebral spaces indicative of thinning of the corresponding intervertebral discs.

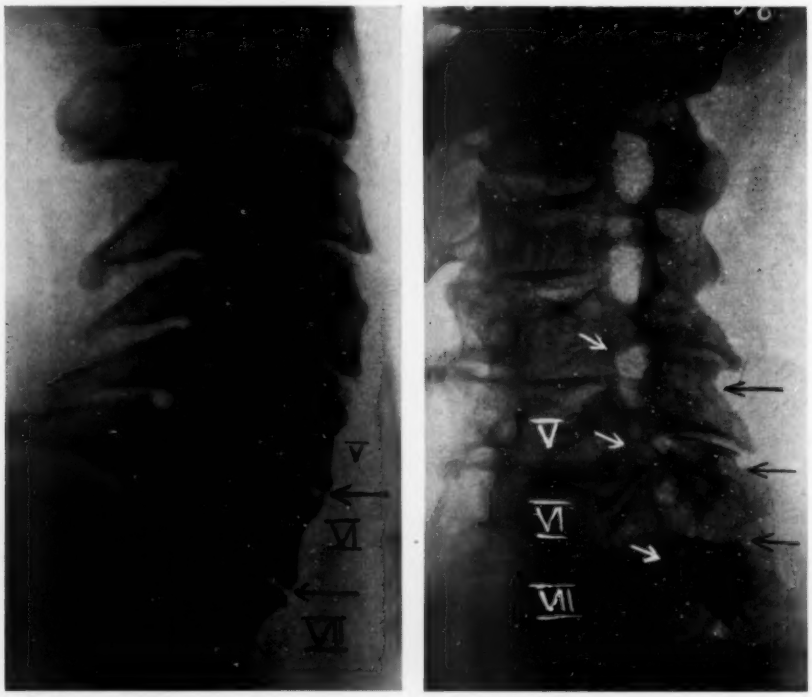
A review of the literature (Schmorl,[13,14] Calvé and Galland,[3] Williams,[17] Keyes and Compere,[4,10] Hadley,[8] Freedman,[6] and others) and a re-examination of 1,500 roentgenograms showing parts of the spine seem to indicate that the abnormalities of the intervertebral discs and the corresponding vertebrae are correlated with the elasticity or hardness respectively of the disc and the vertebral bodies. Softening of vertebral bodies due to infectious, neoplastic or degenerative involvement will make a normal disc protrude into the adjacent cortical layers which give way. More commonly, only the nucleus pul-



a *b*

Fig. 1. Healthy female, aged twenty-two. Lateral, *a*, and oblique, *b*, views of cervical spine. Note that normally, in these projections, the intervertebral space between 7th cervical and 1st dorsal vertebral bodies, as well as the corresponding intervertebral foramen, is a little narrower than in the upper segments. *1*, intervertebral *joint* space; *2*, intervertebral space; *3*, superior articulating process; *4*, normal intervertebral space; *5*, normal intervertebral space; *6*, cross section of spinous process; *7*, intervertebral foramen; *8*, cross section of arch.

posus, as the hardest part of the disc, prolapses into the adjacent bony layers, thereby producing in the vertebral body a circumscribed excavation known as Schmorl's nodule. As this prolapse is often associated with injury to the disc, gradual thinning of the latter may follow. In a second group, it is the primary loss of elasticity or volume of the disc which originates pathological changes. Dehydration, fibrillosis, and traumatic lesions producing leakage of disc substance are known to cause thinning and eventual destruction of the disc, which results in narrowing of the intervertebral space, provided the adjacent vertebral bodies are of normal consistency. The buffer-like action of the disc being thus diminished or eliminated, contact and friction between vertebral bodies occur and result in damage to the bony surfaces with consecutive hyperostotic reaction. This mechanism of production of hypertrophic deformities, which had been made probable by clinical experience, has been conclusively demonstrated experimentally by Keyes and Compere.[4,10] Finally, destruction of discs may occur in diseases of the vertebral bodies. Since the nutrition of the disc is supplied only by lymph diffusing from the spongy bone, infectious and neoplastic material may be transferred from the vertebrae to the discs. Primary infections of the disc have never been observed.

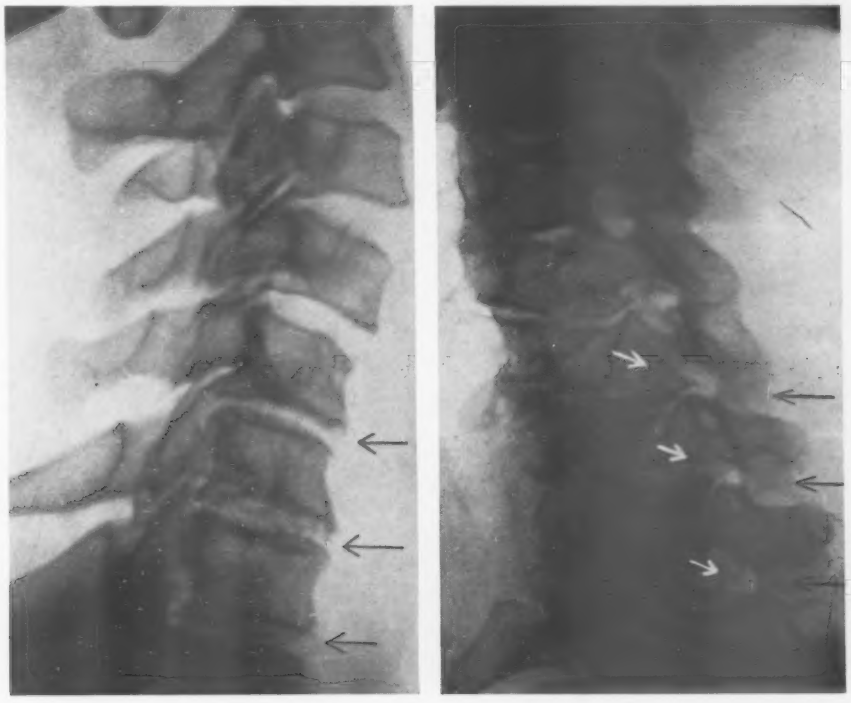


a *b*

Fig. 2. Merchant, aged fifty-three. Long-standing pain in left shoulder. Active elevation of left arm is not possible. Left deltoid muscle thinner than right. Previous diagnoses: rheumatism, aortic sclerosis, "uric acid diathesis," none of which can be confirmed by clinical and laboratory findings. Marked narrowing of 5th and 6th cervical interspaces. Very slight lipping at the adjacent vertebral bodies. Marked deformation and constriction of 5th and 6th intervertebral foramina.

Primary osteoporotic softening of vertebral bodies, as well as primary thinning of discs, may develop after acute trauma of the spine. They are often observed also

in persons over fifty years of age who do not recall having incurred any spinal trauma. Senile changes, faulty posture and the slight repeated traumata of a lifetime have been considered responsible for these conditions. In our material, there are cases presenting only softened vertebrae



a *b*

Fig. 3. Merchant, aged forty-nine. Pain between the shoulder blades, in the upper arms, and the left shoulder, exacerbating during and after long rides. No muscular changes. Active movements normal. Marked narrowing of 5th, 6th and 7th cervical interspaces, with deformation and constriction of the corresponding foramina, *b*. Note that hypertrophic excrescences are limited to the adjacent vertebral bodies only, *a*.

(wide intervertebral space, Schmorl's nodules), others that show only thinning of discs (narrowed intervertebral space). In a number of examinations, however, softening of vertebral bodies was found in the lower section of the spine, and thinning of a few discs without signs of vertebral disease in upper segments. It seems very probable, therefore, that primary thinning of discs and primary softening of vertebral bodies are coördinate signs of the same underlying pathology which, degenerative in nature, may have its origin in disturbances of nutrition. Hypertrophic deformities, such as occur in this disease, have been produced experimentally by interference with the blood supply (Goldhaft, Wright and Pemberton[7]). It is understood that thinning of the disc consecutive to nuclear prolapse is not included in this discussion.

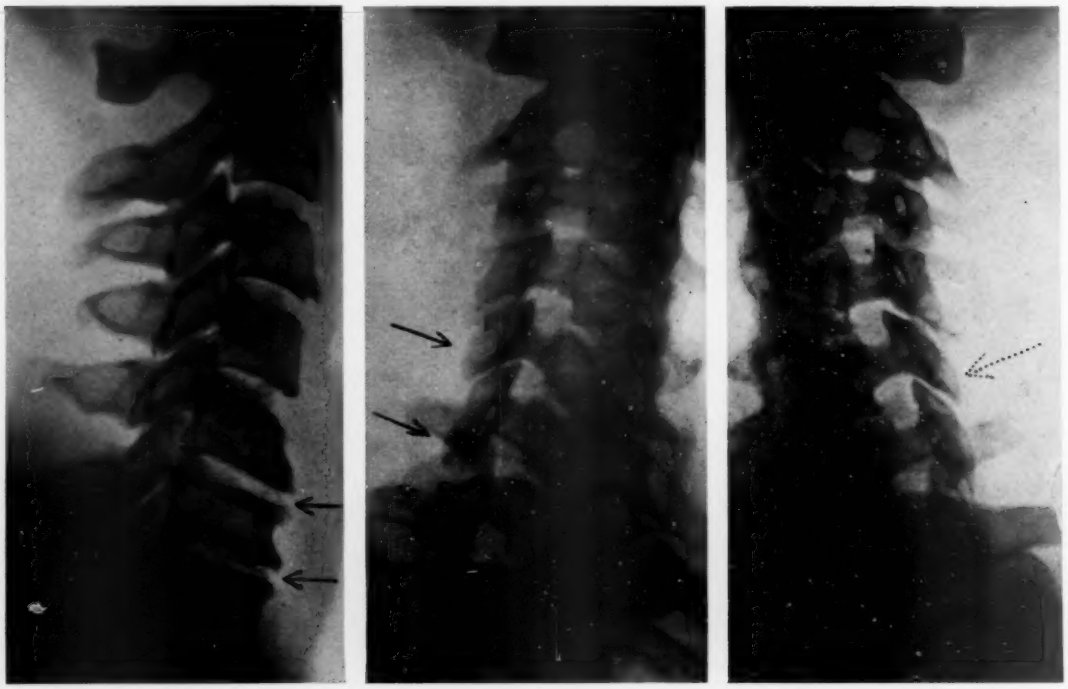
II

Primary thinning of intervertebral discs, which has been repeatedly reported in the lumbar spine, seems to be more common in the cervical spine than in any other segments. It is invariably associated with pain in one or both upper extremities, or in the precordium, or between the shoulder blades, and often with weakness of a group

of muscles and even definite muscular atrophy. Symptoms localized in the neck itself are rare. With two exceptions, our patients did not feel pain in the neck, discomfort, or interference with active and passive movements. Most of them, therefore, would hardly believe that anything was wrong with their neck, especially as they had been treated, often for many years, for rheumatism, arthritis, "uric acid diathesis," or one of the internal diseases mentioned above.

In fact, roentgenoscopy as well as roentgenograms taken during bending and stretching of the neck shows that the flexibility of the cervical spine as a whole is not greatly disturbed as long as four or more discs remain normal. The excursions of the vertebrae adjacent to narrowed interspaces are diminished indeed, but this is largely compensated, during active and passive motion, by the mobility of the remaining segments. It is of particular interest to note that the diminution of the excursions of the vertebrae involved is not necessarily due to fixation such as exostotic bridging over an interspace. A slight movement is often noticeable, which, together with the absence of exostoses, demonstrates that it is the narrowing of the interspace itself which diminishes the mobility. This mechanism, theoretically anticipated by Calvé and Keyes and Compere, is directly demonstrable on lateral roentgenograms.

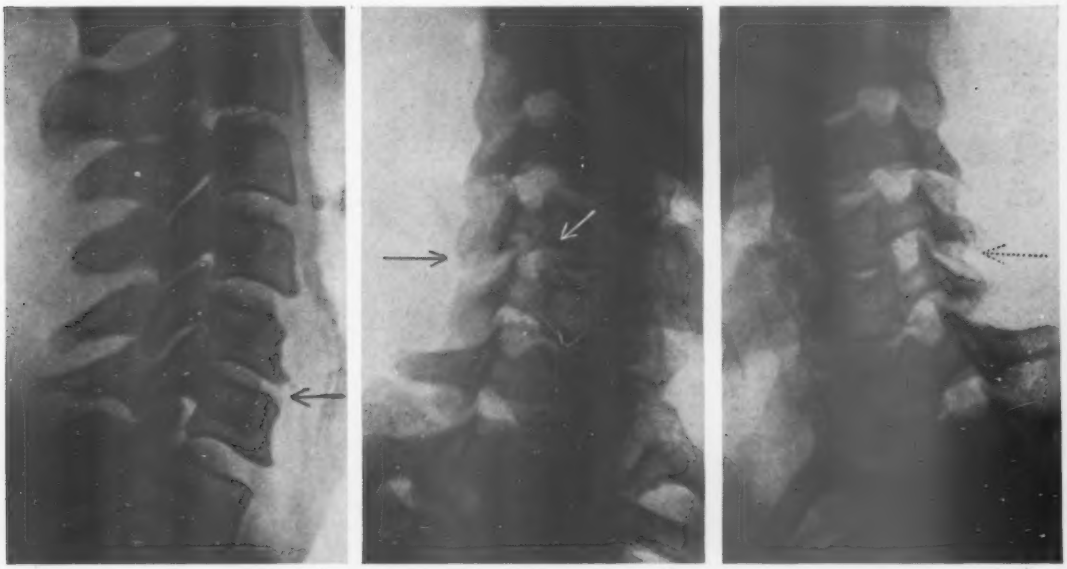
In the majority of our observations, the clinical symptoms had persisted for a period varying between three and seven-



a *b* *c*

Fig. 4. Nurse, aged fifty-four. Felt weakness in right hand three years ago, noticed thinning of the fleshy part between right thumb and index finger one year ago. Recently, right shoulder and right arm became weaker. Pain radiating from right shoulder to right forearm. Active elevation of right arm is almost impossible. Right interossei atrophied. Narrowing of 5th and 6th cervical interspaces with exostotic deformities at the adjacent vertebral bodies, *a*. On the right side, *b*, the 6th intervertebral foramen is narrowed; on the left side, *c*, there is no anomaly of the foramina. In this series, the absence of arthritic changes in the articulating facets is clearly demonstrable.

teen years. In these cases, secondary exostotic changes of the vertebral bodies had developed. The narrowing of the intervertebral space, therefore, was associated with lipping and spiculations of the adjacent bony surfaces. It is essential to note that these exostotic formations were limited in general to the adjacent vertebrae only and that the other vertebral bodies changes were observed in the intervertebral joints. The articular facets of the segments involved did not present arthritic changes. But there was in all cases an abnormal position of the facets. Owing to the reduced intervertebral space, the tips of the superior articulating processes of the lower vertebrae approached the bases of the inferior processes of the upper vertebrae.



a *b* *c*

FIG. 5. Merchant, aged forty-eight. Pain in the right upper extremity and slight weakness of the upper arm. Definite narrowing of 5th cervical interspace, *a*; exostoses strictly limited to the adjacent bodies. Marked deformity and constriction of the right 5th intervertebral foramen, *b*, due to anterior displacement of the superior facet of the 6th cervical vertebra. On the left side, *c*, there is only moderate narrowing of the foramen involved.

did not present similar deformities. The most common localization was found to be the lower cervical portion, especially between the fifth and sixth, and sixth and seventh vertebral bodies.

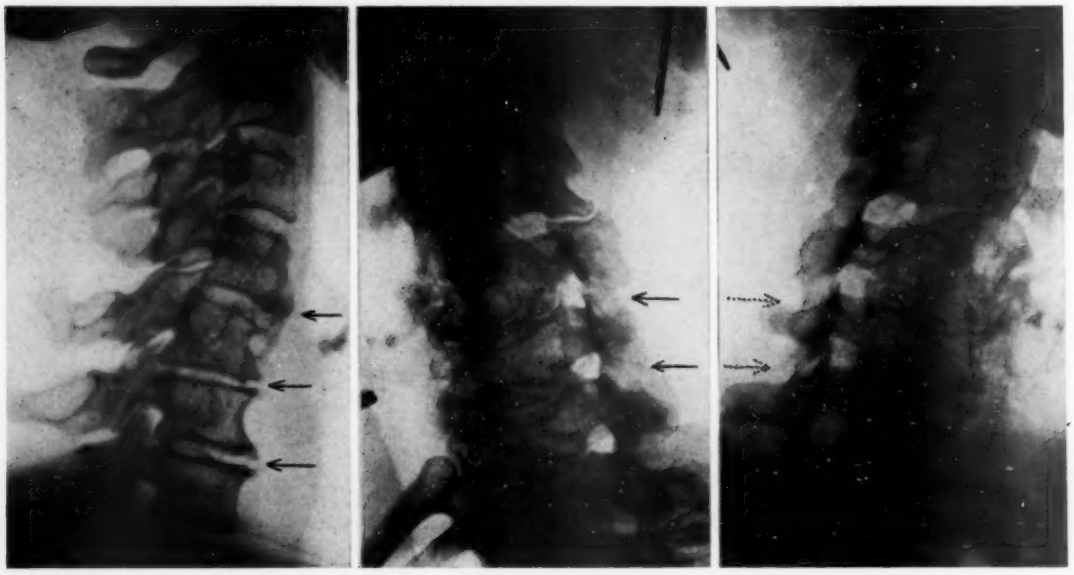
In 4 persons, twenty-five to thirty-two years of age, in 1 woman of fifty-two, and in 3 persons over seventy years old, no hypertrophic changes whatever were demonstrable in the presence of very definite narrowing of one or more intervertebral spaces, although these patients gave a history of long-standing neuritic symptoms.

With one exception, no osteoarthritic

In some instances, this approximation amounted to actual contact between these bones. Similar changes have been observed in the lumbar spine by Hadley.[8]

Narrowing of the intervertebral space obviously produces shortening of the anterior border of the intervertebral foramen, and displacement of the articulating processes shortening of its posterior margin. The narrowing of the intervertebral foramen thereby produced is evident in oblique views of the cervical spine. Normally, the intervertebral foramina appear slightly wider in the upper cervical portion, their outlines are marked by a more or less reg-

ular oval. In the presence of thinned discs, the foramina involved are measurably narrowed and polygonal in outline. This narrowing may be bilateral. In a number of cases, however, it is strictly unilateral. In 2 of these patients, no definite change was observed in the lateral view; the narrowing of the foramen was seen in the oblique position only. In the anterior aspect, a slight deviation of the vertical axis towards the diseased side was present. This combination of findings suggests that the disc may not necessarily be thinned in its whole diameter, but that one side may remain normal for a certain period. Better than any description, the illustrations will show the pathological conditions observed in this disease. In our patients, there was an exact correlation between the peripheral distribution of the nerves involved and the seat of the spinal deformity as found roentgenologically.



a *b* *c*

Fig. 6. Female, aged fifty-eight. Pain in the shoulder girdle and the left arm. Marked narrowing of 5th, 6th and 7th cervical interspaces, anterior displacement of the 4th cervical vertebral body, exostoses of the bodies involved, *a*. Deformation of the corresponding foramina which are narrowed on the left side, *b*, but rather wide on the right side, *c*.

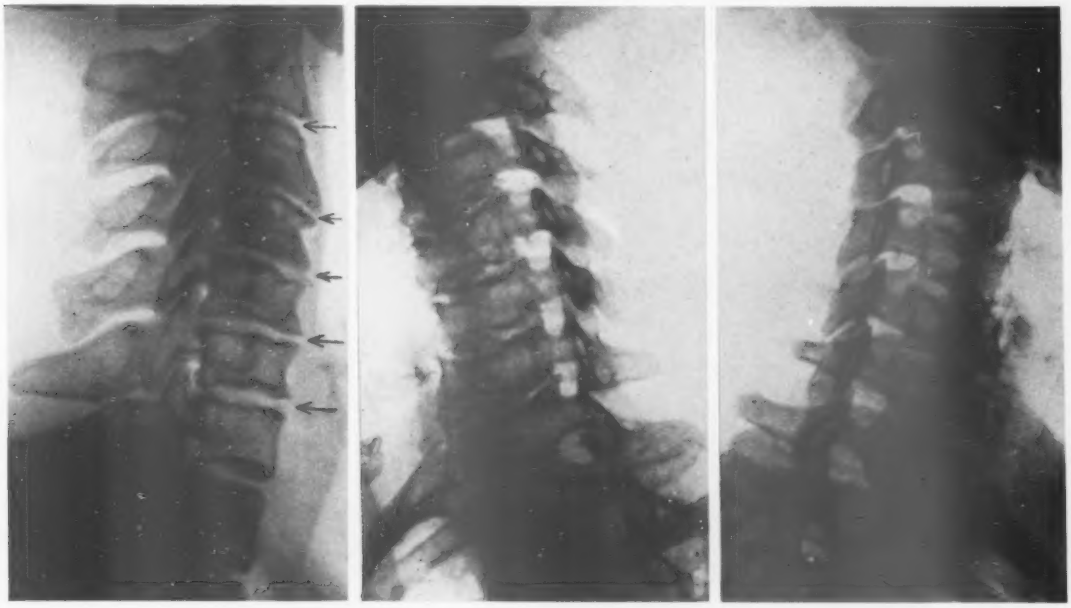
III

Our observations did not make evident any correlation of the lesion described with either systemic spinal or bony anomalies, sex, race, or special constitutional types. Neither is there a demonstrable relation to the type of neck, either short or slender, nor to body weight, nor to the general state of health. In most cases, a careful roentgen examination of the spine did not reveal in other segments anomalies similar to those of the cervical portion. In some instances, however, nuclear prolapse with Schmorl's nodules was found in the dorsolumbar and lumbosacral region. The disease may be met with at any age over twenty years; in our observations, however, persons over fifty years of age predominate. Williams,[17] in his report of a similar condition of the lumbar spine, states that the disease usually begins at the age of thirty.

A relation to severe trauma, such as a fall from a horse, from a ladder, or similar accidents was suggested in several of our observations.

It seems possible that faulty posture may also account for chronic injury to the

discs. Brown[2] has offered this theory as accounting for certain forms of backache. In a number of our patients, the neck was habitually stretched forward, as is typical, for example, of myopic persons. In these individuals, the neck is stretched forward, there is an increased angulation at the junction of cervical and dorsal spine, and the chin points forward with a moderate posterior flexion of the head. This position, of course, is likely to produce unequal static pressure upon the posterior halves of the discs in the lower cervical spine. In this connection it should be mentioned that even very slight trauma may produce severe injury to the disc; for example, displacement of a loosened cartilage towards the spinal cord with resulting compression myelitis (Dandy[5]).



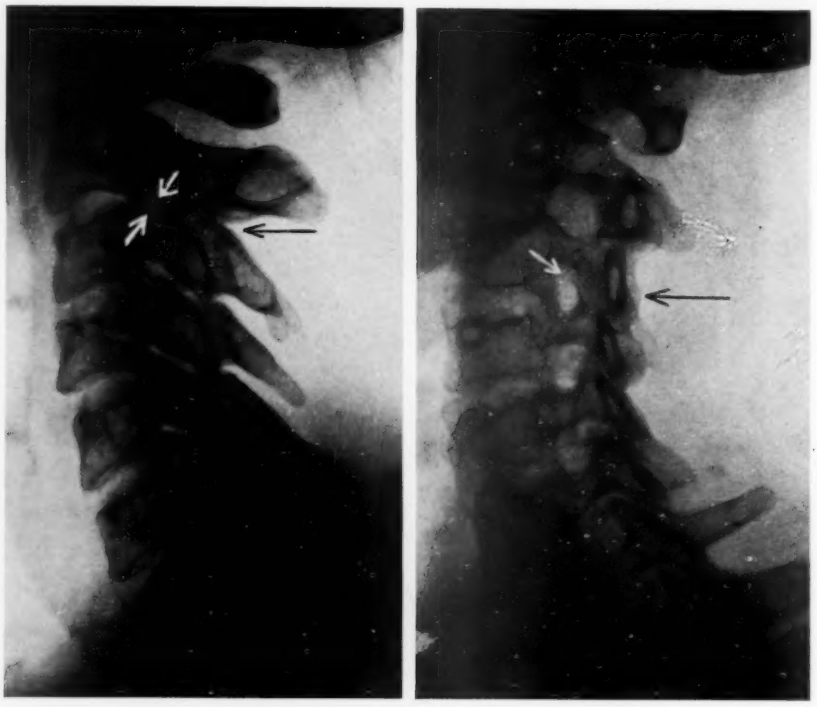
a *b* *c*

Fig. 7. Female, teacher, aged fifty-four. Pain in the left upper extremity for the last eleven years. Great difficulty in elevating the arm, in combing her hair, and in dressing. Except for the 7th interspace, all cervical intervertebral spaces are greatly narrowed. Extensive hypertrophic deformities, *a*. Narrowing of the intervertebral foramina, *b*. For comparison of the diameter of the foramina, the cervical spine of a healthy woman of the same age, size, body weight, and constitutional type is shown in *c*.

IV. CONCLUSIONS

The roentgen findings described make it evident that the radicular symptoms, in this group of cases, are not due to some obscure "arthritic" changes, but are produced by direct mechanical bony pressure upon nerve roots. The disease is a pathological entity within the group of primary disc lesions that produce narrowing of intervertebral foramina. Deformations of the vertebrae, such as lipping and "spiculation," may or may not become visible. If present, they are due to consecutive mechanical irritation of the adjacent vertebral surfaces resulting in exostotic formations. Neither in the literature on the subject nor in our own material have we been able to find, in this disease, any evidence of primary arthritis of the intervertebral joints involved. Primary disease of the cervical intervertebral joints occasionally produces similar symptoms (Fig. 8). Primary arthritis of the spine, however, is a disease quite different from the condition here described; it leads to stiffness, to calcification of ligaments, to ankylosis of the inter-

vertebral joints, but it does not involve, at least not primarily, the intervertebral discs. It should be borne in mind, moreover, that "arthritic" is derived from *arthron*, joint, and applies to joints only. The lack of conformity in the diagnostic evaluation of chronic spinal lesions is partly due to the fact that clinical problems are being confounded with roentgenological aspects, partly to the variable conception of the term "arthritic." There are no other true joints between spinal units than the intervertebral joints formed by the facets. If, for didactic purposes, the interval between the surfaces of the vertebral bodies has been compared to a rudimentary joint, this space, in fact, has neither articulating surfaces, nor synovial membranes, nor does it represent a joint space, as it is completely filled by the disc and its membranes, both of which, moreover, are very strongly fixed to the bodies. The space between vertebral bodies is the intervertebral space, not the intervertebral joint space. The latter term is reserved for the true joint space between the articulating facets. Accordingly, exostotic formations limited to the vertebral bodies are not "arthritic" nor "spondylarthritic," but represent manifestations of a reaction known as hypertrophic or deforming spondylitis (Schmorl's spondylosis defor-



a *b*

Fig. 8. Female, aged forty-eight. Increasing stiffness of the neck. Tingling sensation in the finger tips. Intervertebral spaces perfectly normal in width; vertebral bodies normal; no exostoses, *a*. The 3rd intervertebral foramen, however, is deformed and definitely narrowed, *b*. This is due to ankylosis of the 3rd intervertebral joint, with hypertrophic arthritis of the articulating facets. In this case, the constriction of the intervertebral foramen is not the result of a discogenetic disease, but of a true primary arthritis of one segment of the cervical spine. Compare the width of the normal joint spaces with that of the diseased in the lateral view also, *a*.

mans). Primary disc lesions, although certainly not the sole origin of this deforming process, seem to be a common cause.

These considerations seem to us to justify the expression "discogenetic" disease.

V. SUMMARY

1. Thinning of intervertebral discs causes unilateral or bilateral narrowing of the corresponding intervertebral foramina, which results in compression of nerve roots.

2. This disease is common in the cervical spine where it produces discomfort and muscular weakness of the upper extremities, pain in the precordium or the shoulder girdle.

3. Although, in this condition, the articulating facets are displaced, the intervertebral joints in general do not present roentgen signs of arthritis.

4. Exostotic formations, such as lipping and spiculation, may or may not be present. They are limited to the vertebral bodies, especially to those adjacent to the thinned discs; they are not found in the intervertebral joints.

5. The lesion, in general, is not systemic, but mostly limited to the cervical spine. In some instances, prolapse of nuclei pulposi in lower segments was associated with the cervical lesion.

6. In the classification of chronic spinal lesions, primary thinning of intervertebral discs, regardless of its origin, is a common disease which may often account for insistent symptoms that are clinically obscure.

7. For the sake of brevity, the expression "discogenetic" disease is here adopted.

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THE ROENTGENOLOGICAL CHEST VOLUME FOR ESTIMATING VITAL CAPACITY*

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WAUWATOSA, WISCONSIN

SINCE the fundamental studies of Hutchinson concerning the vital capacity, a diversity of methods has been offered and standards used in this field. The most frequently recommended standards are those based on the height and weight of the body, and the circumference of the chest, stem length, and body surface. If one compares the actual vital capacity of healthy individuals with these standards, the discrepancy between the actual and theoretical values suggests that none of the standards based on bodily measurements is accurate enough to be considered as an ideal gauge for estimating the competency or insufficiency of the cardiorespiratory organs. This fact was convincingly demonstrated by the painstaking studies of Hurtado and Fray.[1] They assumed that multiplying the area of the lung fields, measured in roentgenograms, by the anteroposterior diameter of the chest, measured externally, would secure an accurate value of the true size of the chest cavity. The area of lung fields was measured on the films taken at maximum inspiration by means of a planimeter, the tracer arm of which was moved along the following course: along the inner aspect of the ribs from the left axilla to the left half of the diaphragm, right half of the diaphragm, right lateral border of the lung, right apex, and across the spine to the starting point at the left apex. The result obtained by this method was designated as the roentgenological chest volume. They found that the correlation coefficient between the actual vital capacity and the roentgenological chest volume was higher than that between the vital capacity and body height, chest circumference, area of lung field, body surface area, and chest volume based on external measurements, respectively.

Hurtado and Fray proposed a formula by means of which the vital capacity may be predicted with a fair degree of accuracy from the roentgenological chest volume:

"Vital Capacity (liters) = Radiological chest volume (liters) times 0.24 plus 1.22. The method of calculation is illustrated by an example as follows:

a) The area of the lung fields at full inspiration and measured on the radiological film is 608 cm.[2] The external anteroposterior diameter of the chest at the same respiratory position is 27.5 cm. Therefore, the radiological chest volume is 608 times 27.5 = 16.72 liters.

b) The expected vital capacity is (according to the regression formula): (16.72 times 0.24) plus 1.22 equals 5.23 liters."

The roentgenograms of the chest used for their study were obtained in the recumbent position. The target-film distance was 6 feet. The exposure time was approximately 1/20 second. The kilovoltage was varied according to the thickness of the chest. The milliamperage was 200.

The roentgenograms used in our study were taken from a distance of 6 feet in the upright position. Hurtado and Fray recommended a special planimeter constructed by themselves for measuring the surface area of the chest on the roentgenogram. We found that if one draws a straight line in the middle line and thereby divides the area of the chest into two halves an ordinary planimeter can be used for measuring each side; by adding the two measurements the total surface area is obtained. The figures on the differential wheel of the planimeter used by us indicate areas in square centimeters.

The relationship between the actual vital capacity and the theoretical normal

* From Muirdale Sanatorium, Wauwatosa, Wisconsin.

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values according to six different standards, including the roentgenological chest volume, was studied by us in 65 normal individuals. Their average age was 26.2 years. A summary of the findings is presented in Table 1.

Vital capacities calculated according to the formula of Hurtado and Fray were within ±15 per cent of the actual vital capacities in 97 per cent of the 65 healthy individuals used as controls. This is a higher coincidence than obtained by the other methods based on bodily measurements.

Hurtado and Fray found that the degree of chest expansion can be estimated from the relationship between the areas of the lung fields at maximum expiration and inspiration.

Roentgenograms of the chest at the end of the two respiratory phases were taken on the same film. They used the following technique: The film was exposed at the end of maximum *expiration*, the exposure time being about three-quarters of that in routine roentgenography of the chest. A brass filter, 0.2 mm. in thickness, was then placed over the chest at the level of the diaphragms, and a second exposure of the same length and character was made at the end of maximum *inspiration*. The object of using the brass filter is to prevent over-exposure of the chest, particularly of the diaphragm, during the second portion of the exposure. Much this same effect can be obtained without the use of the brass filter by making the length of exposure at *expiration* approximately five times that of inspiration. They state that if the ratio: (Area at maximum expiration/Area at maximum inspiration) times 100 is higher than 72, a definite reduction in chest expansion may be suspected.

Table I

Relation to actual vital capacity	Roentgenological Chest Volume		Height		Weight		Body Surface		Stem Length		Chest Circumference	
	Cases	Per cent	Cases	Per cent	Cases	Per cent	Cases	Per cent	Cases	Per cent	Cases	Per cent
Within ±15 per cent of actual vital capacity	63	97	49	75.5	52	80	55	84.6	52	80	52	80
More than 15 per cent below actual vital capacity	—	—	14	21.5	7	10.8	4	6.2	13	20	4	6.2
More than 15 per cent above actual vital capacity	2	3	2	3	6	9.2	6	9.2	—	—	9	13.8

In this method a purely roentgenological procedure is offered, by means of which one is able to appreciate the functional competency of the chest without measuring the chest expansion or the diaphragmatic excursions or both.

We have made a study of the relationship between the roentgenological chest volume at maximum expiration and at maximum inspiration. The roentgenograms of the chest in the two respiratory phases were taken on two films. The volumes were calculated according to the formula of Hurtado and Fray. Out of the 65 controls, 40 were studied in this direction. We found that the ratio: (Roentgenological chest volume at maximum expiration/Roentgenological chest volume at maximum inspiration) times 100 was less than 70 in 39

cases. Only 1, or 2.5 per cent of this group had a ratio as high as 70.

A similar analysis was carried out in a group of 40 patients, of whom 21 had silicosis and 19 silicosis associated with pulmonary tuberculosis. Of the silicosis cases, 5 were in the first, 14 in the second, 1 in the third stage, and 1 was an interstitial type of silicosis.

The volume ratio was 70 or more in 24, or 60 per cent, and less than 70 in 16, or 40 per cent. The relationship between the vital capacity, and the "volume ratio" is presented in Table II.

Table II

Volume Ratio 50–59			Volume Ratio 60–69			Volume Ratio 70–79			Volume Ratio 80 and Over		
Serial number	Vital capacity	Percentage below normal	Serial number	Vital capacity	Percentage below normal	Serial number	Vital capacity	Percentage below normal	Serial number	Vital capacity	Percentage below normal
11	2350	−54	3	2700	−45	1	2150	−58	7	2200	−38
13	2800	−30	4	3000	−28	2	1900	−55	22	1300	−67
16	4200	−21	5	4100	−26	6	3150	−35	24	3200	−47
20	4180	−28	8	3500	−31	9	3500	−18	28	2300	−62
27	4330	−17	14	4250	−16	10	2500	−47	35	1600	−71
			15	3700	−26	12	2100	−50	40	3650	−32
			17	3900	−20	18	3500	−23			
			23	3250	−35	19	2700	−52			
			25	4250	−20	21	3100	−29			
			37	2700	−40	26	2900	−35			
			39	3650	− 1	29	2200	−52			
						30	2900	−36			
						31	3200	−34			
						32	2500	−45			
						33	3200	−30			
						34	2900	−30			
						36	3050	−26			
						38	3150	−18			

The vital capacity varied from −17 to −54 per cent, the average being −30, in the group of patients with a volume ratio from 50 to 59. In the group with a volume ratio from 60 to 69, the vital capacity varied from −1 to −45, with an average of −26 per cent. The next group with a volume ratio from 70 to 79 showed vital capacities from −18 to −58, with an average of −37 per cent. The last group of patients with a volume ratio of 80 or more had vital capacities varying from −32 to −71, with an average of −52 per cent.

It may be concluded from these findings that volume ratios between 70 and 79 and particularly those over 80 indicate a considerably reduced vital capacity in the majority of cases.

CONCLUSIONS

1. The roentgenological chest volume is an accurate and practical means for estimating the vital capacity. It is superior to other methods that are based on the bodily measurements. Estimations of the vital capacity calculated according to the formula of Hurtado and Fray were within ±15 per cent of the actual vital capacity in 97 per cent of the 65 healthy individuals used as controls.

2. The "volume ratio": (Roentgenological chest volume at maximum expira-

tion/Roentgenological chest volume at maximum inspiration) times 100 was below 70 in 39 out of 40 normal individuals. It was 70 in one case, or 2.5 per cent, of the controls.

3. The "volume ratio" was determined in 40 patients, 21 of whom had silicosis, and 19 silicosis associated with pulmonary tuberculosis. The "volume ratio" was 70 or more in 60 per cent of these cases.

4. The vital capacity was found to be below normal in patients whose "volume ratio" was between 70 and 80. A diminished vital capacity was particularly evident in patients whose "volume ratio" was 80 or more.

5. A "volume ratio" below 70 was found in 40 per cent of patients with silicosis, and silicosis associated with pulmonary tuberculosis. The great majority of them had a low vital capacity. In other words, a "volume ratio" of 70 or less does not exclude a diminished vital capacity.

6. It appears from this study that a "volume ratio" of 70 or more may be considered an index suggestive of a diminished vital capacity in patients with chronic pulmonary diseases.

THE VALUE AND LIMITATION OF THE OBLIQUE VIEW AS COMPARED WITH THE ORDINARY ANTEROPOSTERIOR EXPOSURE OF THE SHOULDER*

A REPORT OF THE USE OF THE OBLIQUE VIEW IN 1,800 CASES

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SHOULDER pain as a chief complaint is present in 4 per cent of all patients admitted to the out-patient service, and is frequently baffling to the admitting officer, sometimes even to the entire staff. It is true that not every case is perplexing, yet there is a considerable number of cases in the average clinic to warrant reflection. Ridlon[11] confesses "that the difficulties encountered in treatment of injuries to the shoulder joint have always been more troublesome and more obscure than the difficulties in treating all other joints together." These difficulties are primarily due to the limited knowledge of the underlying pathology for the pain in the shoulder girdle.

The advent of roentgenology has helped considerably in explaining some of the shoulder pains; nevertheless, in the majority of cases, the clinician is not appreciably aided by the roentgen examination. Out of 1,800 patients roentgenographed on account of pain in the shoulder, only 581 cases showed roentgen evidence of local pathology in the shoulder girdle. There are several reasons to account for it. Some are anatomical, others are roentgenographic; some are medicolegal, and there is still a group that is really baffling, because the seat of the complaint is not in the shoulder girdle but in pains referred from the cervical spine or the organs in the thorax or abdomen.

(1) *Anatomically*, the shoulder girdle must be considered as a group of joints; the major joint, of course, is the scapulohumeral. (*a*) This joint is very loose to enable greatest range of motion, the glenoid socket small and shallow, and the soft parts very prone to injury. Yet the looseness of the capsule makes the joint capable of harboring an effusion of twice the capacity of another joint without showing on the roentgenogram distention of the joint space. The fact that it is not a weight-bearing joint, but a weight-carrying one, preserves the articulating surfaces much longer than those of the weight-bearing joint, wherein one articulating surface grinds against the other causing early denudation in case of injury or infection, with rapid interference to the blood supply, a resultant erosion of the articulating surfaces, and early manifestation of the pathology on the roentgenogram. Therefore, our roentgen studies of the shoulder joint show very few scapulohumeral arthritides compared with other joints in the body. (*b*) The next joint in importance is the acromioclavicular, very superficial, which partakes more frequently of general serous membrane infections. The findings, however, are more frequently microscopic than macroscopic during the acute stage, the same as in scapulohumeral; again no early roentgen evidence. When the roentgenogram does disclose changes, they are the late effects of a former involvement. (*c*) There is another structure, less superficial than the acromioclavicular joint and mostly lateral, which, although it is not considered by anatomists as a joint, I feel it best for the purpose of a better understanding to think of as such. That is the space between the acromion and the greater

* Approved for publication by the Surgeon General, United States Public Health Service.

tuberosity of the humerus, the deltoid above and the supraspinatus below, with the subacromial bursa between as the articulating surface.* Codman,[1] in his masterly description and evaluation of the subject, says: "How could *this* [this, refers to abduction] occur, unless a *joint* exists between these two bones, and if there were no joint or bursa there, the greater tuberosity would carry its roof, the deltoid muscle, in under the acromion and pinch it." Adding to Codman's concept the frequency of involvement of the acromiohumeral region, we are justified in agreeing with him. (*d*) Then, in the deeper structures of the shoulder girdle, there is occa-

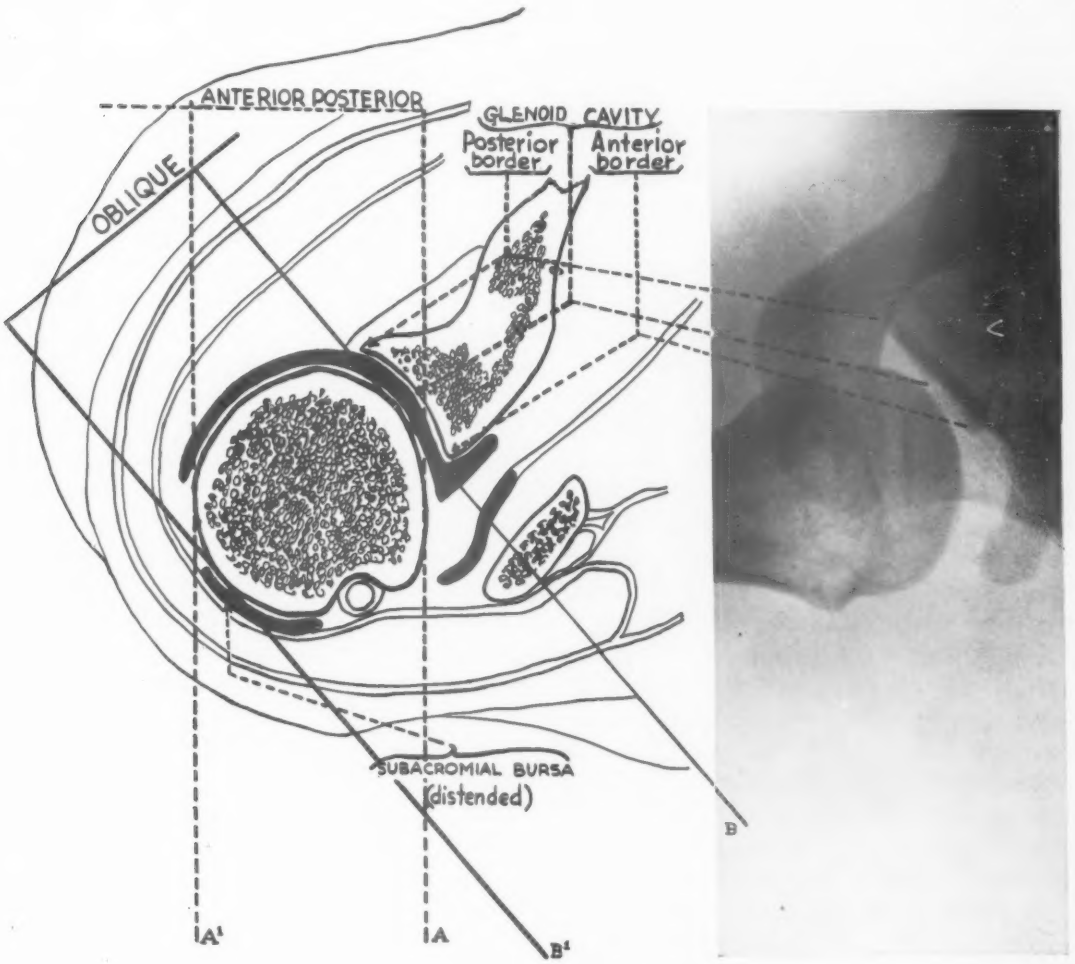

Fig. 1. On the left is a diagram of a cross section of the shoulder girdle at the level of the middle of the glenoid cavity. On the right is a superoinferior view of the same area to show the direction of the plane of the glenoid cavity. The solid line *B*, passes through the plane of the glenoid cavity and is oblique in direction to the coronal and sagittal planes of the body. The other solid line, *B'*, almost parallel to the first, passes through the subacromial bursa and the greater tuberosity at the point of the most frequent location of calcified bursitis (arrow pointing to the subacromial bursa). The broken line, *A*, is the usual course of the central ray of the ordinary anteroposterior exposure of the shoulder girdle. The other broken line, *A'*, almost parallel to it passes laterad to the greatest number of calcified areas in subacromial bursitis. These lines show the advantage of the oblique position for registering the subacromial bursa and the borders of the glenoid cavity.

* This topic deserves a separate consideration and communication.

sionally another joint, the coracoclavicular. In the human it still has the vestiges of a former joint. Cunningham (Anatomy, 1903, p. 267) says "that a synovial bursa usually occupies the re-entrant angle between the conoid and trapezoid ligaments. That is, the first step in the formation of a joint between the coracoid and the clavicle has already been taken." Gregory[7] and Giongo[4] state that in the gibbon and chimpanzee there is a definite coracoclavicular joint. Occasionally a complete joint with articulating surfaces is encountered in the human between the clavicle and coracoid and comes into consideration in evaluating the late effects of dislocation of the acromioclavicular joint with tearing and ossification of the coracoclavicular ligaments. These are some of the anatomical factors which contribute to the difficulty of analyzing pathological states of the shoulder girdle.

(2) The *roentgenographic* difficulties are due primarily to the fact that the joints of the shoulder girdle do not lie in the same or perpendicular plane with reference to the trunk (Fig. 1). The plane of the major joint is somewhat oblique and there is no standard technique for visualizing the scapulohumeral joint in two planes exactly perpendicular to the plane or axis of the joint; in the other joints of the shoulder girdle this difficulty is even more pronounced. The usual exposure is neither parallel nor perpendicular to the plane of the glenoid cavity or articulating surfaces of the acromion (Fig. 1). Hence, signs of early soft tissue changes in the scapulohumeral or acromiohumeral regions are rather difficult to identify on the ordinary roentgenogram of the shoulder girdle. The lateral examination (central ray passing through the center of the glenoid cavity and perpendicular to its plane) is only helpful in fractures or dislocations, but in soft tissue pathology of the scapulohumeral region or the acromiohumeral region the shadows are not sufficiently distinct to enable identification of the joints or their spaces amid all the overlying soft tissue shadows. The axial plane (arm in abduction, tube below and film above shoulder) requires complete abduction of the humerus, a procedure rather difficult in disease of the scapulohumeral joint, also difficult in the more frequent condition of the acromiohumeral region, subacromial bursitis, on account of the faint calcified shadows being often lost in the superimposed shadows of the bone. The examination in abduction and adduction, internal and external rotation, is applicable for definite individual entities (subacromial bursitis, etc.) but not for general routine roentgen examination of the shoulder girdle. Stereoscopic examinations are very rarely resorted to by the surgeon; it requires too much time to view the films, they have to be viewed where there is a stereoscope available, and even then the surgeon very rarely uses them. Although the stereoscopic examination yields more evidence than any other combination of two exposures, especially pertaining to the soft parts, it does not yield as much information pertaining to the bony parts as with the addition of the oblique view herein considered. The disadvantages of the oblique view are the marked difference of density between the medial and the lateral regions of the film, which necessitates viewing by a strong light at varying distances so that the lighter medial part and the darker peripheral part can be seen. However, this difficulty is partly overcome by technique to be described.

(3) *Medicolegal Considerations*. Since industrial accident insurance has become compulsory, there is another difficulty added to the physician's troubles in deciding whether or not the patient's alleged complaint has a basis in the alleged injury, outside of the injury, or none at all. Some patients are very skilled in the art of baffling the physician, especially when they are aware that the physician is the referee for their claim.

In this study, 1,700 of the 1,800 cases came from the Out-Patient Department of one hospital, of which 417 cases were long-

shoremen referred to the clinic by the Referee Commissioner who wanted guidance in the adjustment of patients' claims against the insurance carriers. Of these 389 cases were U.S.E.C.C. patients referred to us by different Federal agencies for treatment, deciding the period of disability and adjusting their claims against the Federal Government. The remaining cases, 867 Merchant Seamen, 27 cases of Coast Guard and Coast and Geodetic Service men, came to the clinic primarily for treatment; yet some patients soon became aware that if they could establish a connection to some previous mishap on this or other ships, they would be entitled to and would receive compensation. As a result, they quickly learned to misrepresent their history, their symptoms and even some signs. The other two above-mentioned classes of patients usually exaggerated their complaints and sometimes have complaints without any grounds except compensation. This is a third reason why so few of our cases show pathological findings on the roentgen examination.

(4) *Referred Pain.* Consideration of this source is very often overlooked in pain of the shoulder girdle. Some of us often fail to remember the intimate relation the phrenic nerve bears to the nerves of the shoulder and to the organs in the chest and abdomen. Ferguson[2] states that the phrenic nerve contains sensory fibers. It arises mainly from the 4th cervical nerve but receives twigs from C3 and C5. From these roots (3, 4, 5) also emerge the suprasternal, supraclavicular and supra-acromial nerves. All of these supply the skin and underlying tissues of the shoulder girdle. Riches[10] states: "The phrenic nerve sends twigs to the pericardium, the pleura, before it pierces the diaphragm, to be distributed on its abdominal surface. Some fibers also join the celiac plexus and thence pass to the peritoneal 'ligaments' of the liver, the supra-renal glands, the inferior vena cava. Occasionally there is a twig to the cystic duct and the neck of the gall bladder. Thus it comes about that stimulation of the nerve endings in any of these locations may give rise to shoulder pain."

Green,[6] Riches,[10] Gilksberg,[5] Podlaha,[9] and King and Holmes[8] find shoulder pains present in diseases of the diaphragm, such as diaphragmatic pleurisy, subdiaphragmatic abscess, empyema; certain lung conditions,—tuberculosis, tumors; abscess, especially if near the periphery or near the diaphragm; certain cardiac lesions with decompensation; major and minor anginas; certain abdominal conditions, such as liver abscess, gallbladder disease, perforated duodenal ulcer or other viscera.

Taking the above reasons into consideration, we can understand why Ridlon[11] mentions that the treatment of conditions of the shoulder girdle is more troublesome than that of all the other joints combined. The difficulties, as one can readily see, are not only in the treatment but also, and more so, in the exact evaluation of the underlying pathological process. Is pathology present? Is it in the shoulder girdle? In what part is it? How can we identify it by roentgen examination?

In our effort to render as much information as possible with the least number of exposures on routine examination, we have chosen the oblique view as suggested by King and Holmes.[8] This communication is a report of the findings of the use of the oblique position for the last eight years at one of the hospitals,* taking the last six years, 1,700 cases, and 100 cases from another hospital,† to see if the 100 cases of another hospital give the same percentages of positive findings without the use of the oblique view. Table 1 shows a gain of at least 4 per cent in positive findings by the addition of the oblique view.

TECHNIQUE FOR ROENTGENOGRAPHY OF THE SHOULDER IN THE OBLIQUE POSITION**

The patient is on the table in the anteroposterior position. He is directed to move away from the center until the scapula of

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† U. S. Marine Hospital, Stapleton, S.I., New York.
** Central ray parallel to plane of glenoid cavity.

Table I

		Equal	More Obvious on Ordinary View	More Obvious on Oblique View	Obvious Only on Ordinary View	Obvious Only on Oblique View	Poor or No Oblique	Totals		Percentage of Pathologic Cases
		Pathology of the Bony Parts—Total cases							281	
Fractures										
Clavicle	Inner third	1	1				2	4		
	Middle third	8	11	2	8		24	53		
4.4%	Outer third	3	4	1			3	11		
	Acromial end	5	4		1		2	12		13.7
Scapula	Body	1	7		1		2	11		
	Neck	3	1		1		1	6		
2.8%	Glenoid	1			1		1	3		
	Coracoid		1			1		2		
	Acromion	8	13	5	1	1	2	30		9.
Humerus	Greater tuberosity	15	10	16	1	1	1	44		
3.4%	Surgical neck	5	3	2			1	11		
	Combined	3	2	1				6		10.5
Torn Supraspinatus Tendon—chipping of greater tuberosity		2	2	5				9		1.5
Dislocations	Clav. acromial end	3	1				4	8		
	Clav. sternal end						1	1		
	Hum. subglenoid	1	1	1				3		
2.1%	Hum. subcoracoid			1				1		
	Hab. dislocation of humerus	2	1	1		1		5		
	Sublux. clavicle	4	9	3			3	19		
	Sublux. humerus						1	1		6.5
Coracoclavicular Ligament Calcification or Ossification		15	12		1		8	36		6.2
Miscellaneous—Giant cell tumor, clavicle—1. Fibrocystic—1. Subperiosteal abscess—1. Osteomyelitis, head of humerus—2		5						5		
		Pathology of the Soft Parts—Total cases							300	
arthritis	Acromioclavicular	23	39	16	5	2	10	95		
5.7%	Scapulohumeral	2	4	1			1	8		17.2
Osteoarthritis	Acromioclavicular	2	13	2	3	2	4	26		
2.3%	Scapulohumeral	1	6	4	3	1		15		
Caries Sicca			2				1	3		7.5
Periarthritis	Combined	3	1	1				5		0.8

Table I (*Continued*)

		Equal	More Obvious on Ordinary View	More Obvious on Oblique View	Obvious Only on Ordinary View	Obvious Only on Oblique View	Poor or No Oblique	Totals		Percentage of Pathologic Cases
		Pathology of the Bony Parts—Total cases							281	
Bursitis	Subacromial, simple	9	1	5		2	1	18		
7.5%	Subacromial, calcified	18	29	54	1	14	1	117		
	Subscapular, calcified	1		1				2		23.5
Synovitis	Acromioclavicular	2	7				1	10		1.7
Miscellaneous	Soft tissue tumor—1	1						1		
		Total Pathological Cases							581	
Os Acromiale		9	8	6			1	24		
Totals		155	193	128	27	25	76			

Under the heading "equal" we have included those exposures in which the findings in the oblique and in the ordinary view were exactly the same. Two observers viewed the films, one the ordinary anteroposterior films and one the oblique views. Their results were checked and the combined vote of all three observers was registered; then the films were reviewed in a different order, and the combined majority vote was taken as final.

Under the heading "poor or no oblique" are included those exposures of the shoulder in which the oblique was technically incorrect, and no reliable information could be gathered from them; in the percentages they were therefore deducted from the grand total.

the shoulder to be roentgenographed is over the center of the Potter-Bucky diaphragm. The lateral border of the arm and shoulder is 3 in. from the midline of the Potter-Bucky. The opposite shoulder is then raised to within 45° of the perpendicular to the table. This brings the scapulohumeral joint over the center of the table. The opposite shoulder is held in position by a large sand bag.

A large compression bag, half filled with water (water phantom), is placed alongside the shoulder to be roentgenographed, so that the water spreads evenly at the upper and lateral borders of the shoulder girdle. The patient pulls on the inflating tube of this bag with the opposite hand, the rubber bag being close to the chest or attached by a piece of adhesive, to the opposite axilla. If patient is unable to lie on the table and the shoulder is taken in the standing position, an aluminum wedge 20 cm. long by 15 cm. wide and from 1 cm. in thickness at the outer edge to 0.1 mm. at the inner edge is placed over the shoulder with the thicker edge toward the lateral border to compensate for thinness in tissues at the lateral border.*

The tube is centered over a point 1½ in. medially and below the upper-outer border of the shoulder girdle, at the midline of the table. The central ray is directed perpendicular at this point. The tube setting is proportional to the thickness of the part in inches; the gap or kilovolt (peak) is 40

* The logical impression one gets is that the addition of the water or the aluminum wedge to the tissues to be roentgenographed is a step backward; yet the facts are somewhat different. The shoulder girdle has a uniform density and all soft and bony parts are almost seen at once without the aid of different strength of illuminators. This form of compensating with water phantom has not only an application in the shoulder but we have used it also in all other parts where different thicknesses of body tissues are taken on the same film, e.g., anteroposterior view of foot or entire body on one film. The greater uniformity in density compensates for the slight loss in detail. Especially is this of advantage for the busy roentgenologist.

plus 4 times the thickness of the part in inches. Example: 4 in. thickness of the shoulder, through the scapulohumeral joint will require $4\times4+40=56$ kv. (peak). The milliampere-seconds is also proportional to the thickness; with use of the Potter-Bucky diaphragm and fast screen and fast film, a 4 in. part with the water phantom would require 60 ma-sec. A 6 in. part would require 90 ma-sec. If screens are slow, more time is required. Example: 60 ma-sec. in machine delivering 20 ma. will be 3 sec.; 10 ma. would be 6 sec., etc. In other words, the product of the number of seconds by the number of milliamperes should be 60 for a 4 in. shoulder, with use of additional water phantom. The distance is standard 30 in.; if greater distances are desired for finer detail, proportional increase in the kilovoltage or time is essential. If no water phantom or aluminum wedge is used, the milliampere-seconds is one-half of the above described.

Anatomical Limits. To better understand the abnormalities of the shoulder girdle as seen in the oblique position, it is advisable to review the roentgen anatomy of the normal shoulder, particularly with reference to the soft parts as seen on the oblique exposure. The scapulohumeral joint appears like a slit of diminished density between the articulating head of the humerus and the glenoid cavity, about $\frac{1}{8}$ in. in width. Sometimes there is a very thin, dense, crescent, linear shadow, about $\frac{1}{16}$ in. in thickness, at the lower two-thirds of the glenoid cavity. This is the shadow of the normal joint cartilage and evidences very good technique or beginning calcification; the latter is sometimes seen with advancing age. The anatomical neck of the humerus shows a minute depression at the junction with the greater tuberosity, notch-like in appearance. At the periphery of the greater tuberosity, there is a slight condensation of bone with radiating striae extending downward and also laterally and inward, from $\frac{1}{4}$ to $\frac{3}{8}$ in., in all directions. These striae are more prominent with atrophy, either from disuse or other source.

Just above the highest point of the head between the acromion and the greater tuberosity of the humerus, there is a faint, dense tissue shadow with a distinct border, the border is about $\frac{3}{16}$ to $\frac{5}{16}$ in. above the anatomical neck. This shadow is cast by the tendon of the supraspinatus muscle and is obliterated in contusions of the shoulder. At a point about $\frac{1}{4}$ to $\frac{1}{3}$ in. above this shadow and continuing from the acromion to the junction of the upper and middle thirds of the humerus over the greater tuberosity, there is a faint dense shadow caused by the border of the deltoid muscle. Sometimes there is an additional border over the greater tuberosity, beginning at the acromion, more distinct and separated from the rest of the shadow of the deltoid, due to a tendinous part within the deltoid muscle; its length is about 2 in., thickness from $\frac{1}{8}$ to $\frac{3}{16}$ in., seen in some strong, muscular males. The soft tissue shadow above the notch of the neck of the humerus, from notch to nearest skin border was from 20–30 mm. in normal adult males. The subdeltoid bursa casts no shadow when normal.

The groove between the greater and lesser tuberosities of the humerus is frequently seen, limited medially by the lesser tuberosity ridge density, at a point about $\frac{1}{4}$ in. from the periphery, from $\frac{3}{4}$ to 1 in. in length. Sharply demarcated rounded bodies are occasionally seen medial to the lesser tuberosity, the largest one was (in the series of 1,800) not greater than the size of a pea, and usually in the location of the subscapularis tendon. Less frequently, we found small dense bodies in the region of the attachment of the tendon of the infraspinatus or teres major and minor. We found no sesamoids under the supraspinatus tendon. The position of the head of the humerus with reference to the glenoid cavity varies; the lower border of the head may be $\frac{1}{4}$ in. below the lower border of the glenoid cavity when the arm is parallel to the side of the chest; with traction it can appear $\frac{3}{8}$ in. below the border of the glenoid cavity. It may be as high as $\frac{3}{8}$ in.

above the lower border of the glenoid cavity. If, however, these limits are surpassed, there is evidence of injury to the capsular ligament or a relaxed capsule. The clavicle is very poorly seen in this view on account of foreshortening.

The acromioclavicular joint is also foreshortened and appears fused. The superior border of the acromion appears below the superior border of the clavicle, and sometimes has an additional center that might be mistaken for a fracture. This center of ossification is about $\frac{3}{4}$ to 1 in. in length, about $\frac{3}{8}$ to $\frac{1}{2}$ in. in height and, if persistent after twenty-five years, is called os acromiale.

The ordinary anteroposterior exposure of the shoulder is really not a true anteroposterior of the joint since the central ray is not parallel to the surface of the glenoid cavity, as can be seen from Figure 1. It shows, however, all the findings enumerated in the oblique view, not as prominent, the only exception being that the head of the humerus casts its shadow on the shadow of the posterior third of the glenoid cavity, and does not show the scapulohumeral joint as clearly as the oblique exposure. However, the acromioclavicular joint outlines better. The articulating ends of the acromion and the clavicle are about $\frac{1}{4}$ in. apart (the space is occupied by the articular cartilage, only rarely identified on the roentgenogram), with variation of $\frac{1}{8}$ in., depending on the habitus of the patient; the thinner the patient is, the flatter appears the joint; the stouter the patient is, the wider is the space. The older the patient, the rougher are the borders of the acromioclavicular joint and the peripheral end of the acromion.

At the inferior border of the glenoid cavity and for about $\frac{3}{4}$ in. below it, there is a small roughened prominence on the scapula (for attachment of long head of triceps), which is sometimes mistaken for periostitis. The borders of the glenoid cavity also show roughening with increase in age, and greater muscular activity. Occasionally there is a delay in union of the epiphysis

Fig. 2. This shows a fracture of the greater tuberosity of the humerus seen in the oblique position, *A'*, and missed entirely on the anteroposterior view, *A*. It is only after seeing the oblique view that the fracture could be identified on the anteroposterior view.

of the scapula, or acromion or coracoid, or head of the humerus, or combination (possibly due to disturbance of the internal secretion), that one has to guard against not to interpret as fractures or periostitis. The os acromiale, when present, appears to be superimposed on the shadow of the acromion, and reaches to about $\frac{1}{8}$ in. above the superior border of the acromion. The inferior border of the os acromiale reaches to about $\frac{1}{4}$ to $\frac{3}{8}$ in. below the highest point of the acromion.

The results of the study of the 1,800 shoulder girdle cases in the ordinary and in the oblique views are best summarized and compared in Table 1. We note that there were 581 cases showing local pathology on the roentgenograms. This constitutes 32.2 per cent of the 1,800 cases complaining of pain with or without other discomfort in the shoulder girdle. These findings compare fairly well with those of King and Holmes of Massachusetts General Hospital, who

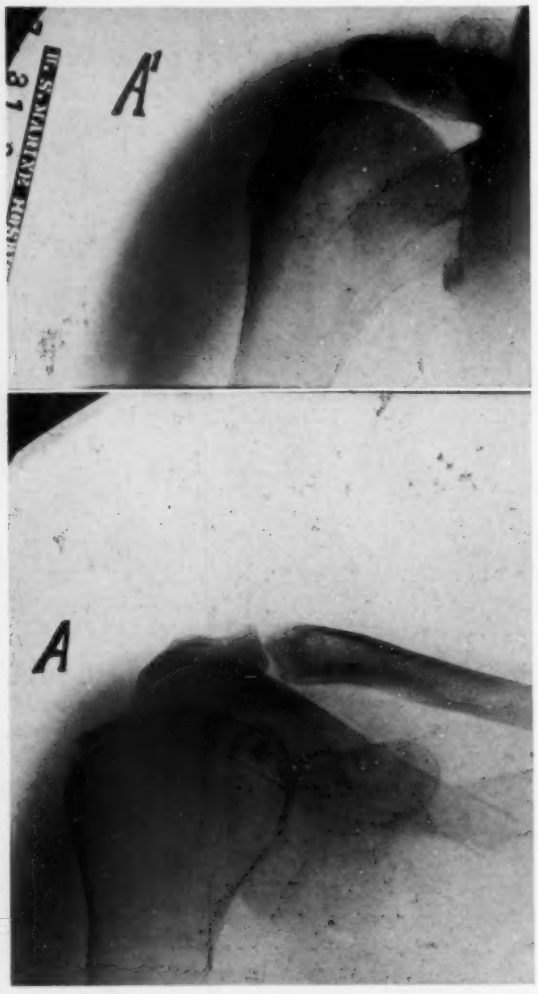

Fig. 3. The lower half shows an ordinary anteroposterior exposure, *A*, in which a diagnosis of calcified bursitis of long standing was concluded with two separate masses, but the oblique view, *A'*, shows the lower mass due to old calcified bursitis while the upper mass of dense tissue is due to a recent fracture of the greater tuberosity of the humerus with separation of the tuberosity fragment, posteriorly.

found 33.4 per cent positive local pathology in the shoulder girdle examinations. The small difference of 1 per cent might be accounted for by the fact that our cases are taken from the Out-Patient Department alone; and their cases were taken from both the Out- and In-Patient Departments. Furthermore, our material was almost 50 per cent compensation cases, wherein the medicolegal aspect is an important factor in the complaint resulting in fewer positive local findings. Yet their number of positive local shoulder findings was diminished by the greater number of cases of referred pain from the chest or abdominal organs.

In the upper half of the table, the findings pertaining to the bony parts total 281 cases—48.2 per cent of the total of the pathological cases, while 300 cases show pathology found in the soft parts—51.8 per cent of the pathological cases. This is in great contrast to the cases reported by King and Holmes,[8] which showed only 64.7 per cent of all cases with pathology in the group of fractures and dislocations, while 35.3 per cent were in the group of soft tissue pathology. On careful evaluation of the findings, we note that in the column "equal" the majority of cases of bone conditions are included under it, suggesting, therefore, that cases of fracture can be seen equally as well on the oblique as on the ordinary exposure. We find, however, that in cases of fractures of the middle third of the clavicle, 8 out of 24 were not seen at all on the oblique exposures; 2 were seen best on the oblique exposure, 11 were seen better on the ordinary exposure, and 8 were seen equally as well on the oblique as on the ordinary exposure.

In contrast to this finding, we have in fractures of the greater tuberosity (Fig. 2), 16 which were best seen on the oblique exposure, 10 were best seen on the ordinary exposure; 15 were seen equally as well on the ordinary as on the oblique exposure. In fractures simulating bursitis, the oblique view was found a more reliable source of diagnosis (Fig. 3).

The reason that the oblique position is more helpful in diagnosing fractures of the greater tuberosity and subdeltoid bursitis lies in the fact that the greater tuberosity is an anterolateral structure in the ordinary position. When the forearm and hand rest on the chest, the greater tuberosity shadow is lost in the shadow of the posterior part of the shaft and neck. If, however, the forearm is held at right angles to the arm and

turned outwards until the forearm rests on the table (King and Holmes),[8] fractures of the greater tuberosity will not be missed, the outward rotation of the shaft of the humerus making the greater tuberosity a lateral border structure. The same is true with calcification in the subdeltoid bursa. Although the greatest part of the bursa is posterior, the most frequent site of calcification (61 out of 117 cases) is anterior, close to the bicipital groove. By the outward rotation of the humerus, therefore, the region becomes a lateral border structure and is more easily identified on the film.

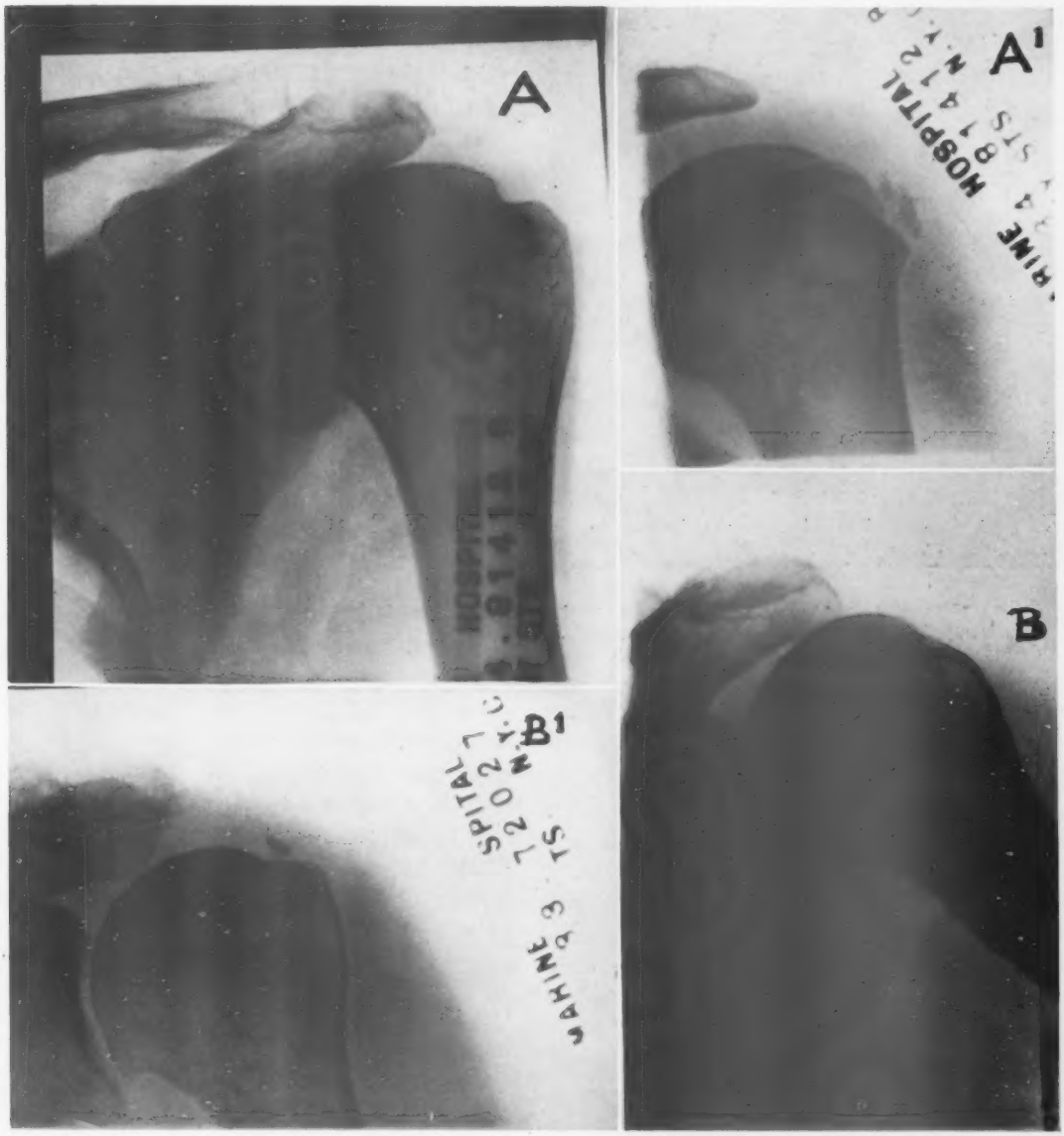

Fig. 4. The upper half compares the ordinary anteroposterior exposure, *A*, humerus in outward rotation, in a case of subacromial bursitis which could not be identified on this film. It was only after viewing the oblique view, *A'*, that a definite diagnosis of calcified subacromial bursitis could be made. The same was true in the other case shown here. It was after these calcified shadows were observed in the oblique views, *A'* and *B'*, that they were in part identified on the ordinary views, *A* and *B*.

Fig. 5. This shows two different types of os acromiale, occasionally mistaken for fracture.

In conditions of the soft parts we find that arthritis and osteoarthritis of the acromioclavicular joint were better seen in the ordinary than in the oblique exposure in 39 out of 95 cases, and were seen only twice in the oblique view alone, although in 5 cases they were seen on the ordinary view alone. On the other hand, in calcified subdeltoid bursitis, we find the opposite is true. Out of 117 cases, 54 were best seen in the oblique position and 14 were seen in the oblique position without being seen in the anteroposterior view (Fig. 4). Nine cases were seen in the ordinary better than in the oblique position; 18 were seen evenly, and only 1 was seen in the ordinary without being seen in the oblique position. In simple subdeltoid bursitis the relation is also about the same. Out of 18 cases, 5 were best seen in the oblique, 1 was best seen in the ordinary position; 9 were seen evenly and 2 were seen in the oblique only, without being seen in the anteroposterior view, but none were seen in the ordinary without being seen in the oblique position.

It is interesting to note from the above findings that the most frequent pathological condition in the shoulder girdle examinations is subacromial bursitis, simple and calcified, totalling 135 in our series. The next in frequency is acromioclavicular arthritis. In pathology of the bones, the most frequent fracture is that of the middle third of the clavicle and next in frequency is fracture of the greater tuberosity of the humerus. Third in frequency are injuries of the coracoclavicular ligaments with calcification and ossification. This entity usually results from a severe trauma to the acromial end of the scapula with acromioclavicular dislocation as the usual diagnosis. The coracoclavicular injury is entirely overlooked. This continues to be the source of litigation in industrial medicine because of late appearance of the condition and continued impairment to the lifting power of the arm. The point deserves separate study with separate report.

The os acromiale is also included in this study but not as a pathological finding. It is interesting to note that it occurred in 24 out of 1,800 shoulder girdle examinations, and its appearance was seen equally well in 10 out of the 24 in the ordinary as in the oblique exposures, seen better in the ordinary 8 times, in the oblique 6 times; when seen better in one exposure, it can also be seen in the other. It is included here to show its frequency and guard against mistaking it for a fracture, recent or old (Fig. 5).

COMMENT

This subject has been presented in an effort to stimulate better understanding of the various major and minor affections of the shoulder girdle, particularly among those clinicians who have large clinical material at their service. It is hoped that a careful study will be made of the various clinical findings associated with these roentgenological "so-called entities," and that the better correlation of symptoms and signs will be evidenced in order to

enable the general practitioner to think of other possibilities besides scapulohumeral arthritis and subdeltoid bursitis.

SUMMARY

One thousand eight hundred roentgen examinations of the shoulders of patients from the Out-Patient Service of the U. S. Marine Hospital, New York, whose chief complaint was pain, was reviewed. Of these only 32.4 per cent showed local pathology in the bone or soft structures of the shoulder.

The most frequent fracture of the humerus was that of the greater tuberosity —44 cases. The oblique view showed the pathological process better than the ordinary view in 37 per cent, and it was seen only on the oblique view in 2.3 per cent of the cases.

The most frequent pathological process of the soft parts was subacromial bursitis. The oblique view showed the pathological process better than the ordinary in 43.6 per cent of cases. The oblique view showed exclusively 11.8 per cent of all cases of subdeltoid bursitis.

In fractures of the clavicle and in acromioclavicular arthritis, the oblique view fell 10 per cent short of yielding the same positive findings as the ordinary view.

The oblique view cannot be substituted for the ordinary view, but should be used as an accessory exposure because at times it is the only source of roentgen evidence for pathology in the region of the shoulder girdle—25 out of 581 positive cases in our series.

I wish to express my gratitude to Senior Surgeon E. R. Marshall for his kind cooperation, and to Miss Dorothy Hartman, Winthrop D. Conklin, and Hymie Vozick, for their untiring cooperation.

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THE RADIATION TREATMENT OF HYPERTROPHIED LYMPHOID TISSUE OF THE PHARYNX AND NASOPHARYNX*

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IN A former report, a preliminary survey of the literature was given on the use of irradiation in the treatment of hypertrophied or infected lymphoid tissue.[2] In a short summary of this literature, we find only recently references to the therapeutic irradiation of infected lymphoid tissue, other than through the tonsils.

Prior to 1920, Warthin[4] gave a most detailed report on research work done and on cases treated. His findings as to the direct action on the lymphoid cells are still recognized.

Regaud and Negier, however, in 1913, had irradiated lymphoid tissue in their study of reactions of various tissues of the body to the roentgen ray. No clinical application was made of this information.

Witherbee,[7] in 1921, reported his first case that had been subjected to this method of treatment; one that he had treated two years previously, in 1919. He and his coworkers[8] soon thereafter reported a series of 46 treated cases. They discovered, among other things, a marked shrinkage in the size of the tonsils, and a marked reduction in the bacterial count in cultures taken from tonsillar crypts. The effect was found to be the most marked on the hemolytic streptococci. This lowered bacterial count was attributed to the improved drainage of the crypts by the decrease in size of the lymphoid structures. To these workers is given the credit of stating specifically that roentgen rays had been used by them in treating lymphoid hypertrophies.

Waters, MacCready and Hitchcock[5] did not observe that the bacterial count was reduced in the tonsillar crypts following irradiation, and stated that the irradiation, in their opinion, was rather limited in its application. Their most satisfactory results were found in the simple tonsillar hypertrophies, where there was an excess of lymphoid tissue. This conclusion was substantiated by the same authors in the following year. MacCready,[3] in 1925, summarized the results obtained by Waters and his coworkers over a three year period. Fourteen cases had been followed during this time. The outstanding features were the reductions in frequency of head colds, and other upper respiratory infections. He concluded that surgical treatment was indicated where there was obvious infection of the tonsils, in contrast to simple hypertrophies.

During this period, numerous articles appeared in the medical journals on this subject, indicating a great period of activity. During 1922, many enthusiastic workers were reporting satisfactory results, many of which were grossly exaggerated, partly accounting for the decline and the bringing of this method of therapy into disfavor.

Radium and radium emanation soon began to replace roentgen rays because of greater ease of application, and many articles on this method of treatment appeared in the literature. Wells,[6] in one of the earliest papers on the use of radium in the treatment of tonsils, was doubtful about the reduction of the bacterial count, following irradiation, but only noted the atrophy of the tonsillar structures.

The irradiation of tonsils in certain selected cases and when administered by a competent radiologist is still occasionally the method of choice. In our publications, we refer to the non-encapsulated lymphoid tissue which is present over the pharynx and nasopharynx, most of which cannot

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be removed surgically. These follicles are usually scattered over the entire posterior and lateral walls of the pharynx. They vary in size from a few millimeters up to 1 centimeter in diameter. They are usually infected with mixed organisms of the nasopharynx and the patient's chief complaint is usually the recurrent acute flareups, consisting of frequent colds, excess mucoid discharge, post-nasal dripping, cough and even gastric irritation. There are also systemic disorders which may be traced to the toxins liberated from the infection of this lymphoid tissue, such as neuritis, arthritis, and asthmatic bronchitis.

The organisms most frequently found in hypertrophied lymphoid tissue are streptococci, but occasionally one finds diphtheroids, Vincent's spirochetes, and fusospirochetal organisms. If the latter are found, the usual treatment is carried out, but this does not prevent recurrences. In many cases, the pharynx has been painted and swabbed with every type of chemical antiseptic known, gargles of all types have been used, but, unfortunately, the otolaryngologist knows very little about radiation therapy.

Over a period of six years, approximately 300 patients have received radiation therapy in our hospital. Of this number, 189 have completed treatment; some of the remainder we referred to radiologists in other cities for conpletion of the treatments. Of the above group, all except 2 had had their tonsils and adenoids removed previously. In a few patients, there were remaining tonsillar remnants, which were removed by a dissection before the pharyngeal tissue was irradiated. A careful followup is being made by the otolaryngologist and will be reported in a subsequent paper.

The technique of irradiation in these cases has been standardized during the last few years. The dosage was carried out under the following conditions: 100 kv., constant potential, 5 ma., 25 cm. distance, and 3 mm. aluminum filter. The dosage used is 100 r, administered over each side of the neck at weekly intervals, giving from four to six treatments in a series. This dosage in some patients produced considerable dryness of the nasopharynx; therefore, where possible, the treatments are given at two-week intervals, using 150 r, as the dosage over each side of the neck, and a 4 cm. area over the bridge of the nose.

The immediate reaction depends somewhat on the degree of infection of the lymphoid tissue. This reaction is characterized by a congestion and swelling of the cervical nodes, often only a few hours after the treatment. This reaction of lymphoid tissue to irradiation has been fully discussed by Akaiwa and Takeshima[1] in a recent article. They stress the fact that the follicles lose their reddened granular appearance and are replaced by fibrous tissue. We use this as a criterion in determining the ultimate dosage. Some are more radiosensitive than others and require a smaller amount of treatment.

CONCLUSIONS

The irradiation of hypertrophied tonsils was finally abandoned in favor of surgical removal. The hypertrophied lymphoid follicles of the nasopharynx are always predisposing factors in head colds, neuritis, arthritis, and asthmatic bronchitis. The technique of irradiation is fractional doses of low voltage roentgen rays given in the same manner as in chronic infections elsewhere in the body.

There can be little argument against this method of therapy as very often satisfactory results are obtained after all other methods have failed.

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RADIUM VERSUS ROENTGEN RADIATION IN THE TREATMENT OF BENIGN UTERINE BLEEDING*

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IT HAS often occurred to me that a definite answer has never been given to the question of the superiority of radium or roentgen radiation in the treatment of benign uterine bleeding. Indeed, there seems hardly to be any question concerning it. Either one or the other agent or a combination of them is reported by various authors without much being said as to the reasons for the choice of the therapeutic agent. A little speculation and a cursory review of the literature convinced me that we might well pause and consider this choice of remedial agents.

Of course it is well recognized that there are many cases in which there are special considerations which point definitely to one or the other of these agents as the one of choice. We are all familiar with these circumstances. There remains, however, a large number of cases in which the choice of irradiating agents is to be made by the physician without the benefit of prescribed precedent, or logical scientific reason. It is concerning this group that I wish to raise some questions.

It is generally admitted that the biological effects of the roentgen ray and radium are identical. It is also found in a rather extensive survey of the literature that the favorable results, so far as the control of bleeding is concerned, occur in about the same percentage of cases in patients treated by these two agents. We must therefore look for more subtle differences between them on which to base an opinion as to their relative merits.

One gains the impression from the literature that in many instances the choice is one of expediency. In view of the fact that so little difference in the observable results exists, this is perfectly proper. But may there not be some as yet little recognized effect of one or the other of these agents which may well sway the choice more predominantly in its direction.

I have for some time sensed that those patients who had received only roentgen radiation progressed more satisfactorily than those who had received radium or both radium and roentgen radiation. This has been nothing more than a clinical impression and the reasons for it are entirely too vague and subtle to be reflected in tables of statistics or to admit of mathematical formulation. The impression hinges on such factors as the general feeling of wellbeing of the patient while under observation, the extent of psychic trauma incident to the procedure, the mental attitude, the number and severity of post-treatment complaints and the relative smoothness of the patient's life in medical matters in the years subsequent to the treatment. In spite of the fact that there is little of concrete evidence concerning such matters, I do feel that the roentgen treatment of benign uterine bleeding gives better results in these respects than does radium. I feel that the slowly induced, artificial menopause progresses more evenly and with less ill effect upon the patient when induced by roentgen irradiation and that there are fewer instances of distant ill effects that might be attributed to the procedure.

Before committing oneself to favoring the roentgen ray, however, it is desirable to carefully weigh the relative merits of the two types of radiation. Also it may be pertinent to inquire as to the possibility of over-irradiation of the endometrium during the use of radium to secure sufficient ovarian effect; necessarily the endometrium and muscularis of the uterus will receive considerably more radiation when radium is used than when the more diffuse roentgen ray is used. Is there some effect

* Read at the Twenty-first Annual Meeting, American Radium Society, Kansas City, Mo. May 11–12, 1936.

on the circulatory and vegetative nervous systems incident to the unequal intensity of radiation induced by radium that could be ameliorated by the diffuse radiation of the roentgen ray? The literature is of surprisingly little assistance. Very few reports concern themselves with long time follow up on treated patients, and those that do mainly confine themselves with such questions as the occurrence of pelvic pathology or other concrete evidences of the difference between the two agents.

In order to obtain a representative view, a limited number of radiologists considered to be a cross section of this Society were asked their opinions on this subject. Their answers were rather divergent and summarized, they are as follows:

Arthur C. Christie: Favors roentgen radiation. End-results are as good as radium. More agreeable, less expensive. Avoids hospitalization.

William E. Costolow: Favors combination of roentgen radiation and radium in ages around menopause. Radium in younger women to avoid damage to ovaries.

Edwin C. Ernst: Favors roentgen radiation because after-effects are more favorable. Based on 3,900 cases.

Charles L. Martin: Favors radium because he thinks curettage should be done in every case and radium can be conveniently inserted at the same time.

Leon J. Menville: Favors roentgen radiation except when pathology is strictly endometrial.

Benjamin H. Orndoff: Favors roentgen radiation and radium for all tumors except the very large ones, for which he favors roentgen radiation.

George E. Pfahler: Favors roentgen radiation if the bleeding is due to ovarian hyperfunction; radium, if due to endometrial pathology. Exceptions due to special circumstances.

Edward H. Skinner: Favors roentgen radiation for patients he has opportunity to treat several times. Radium for out of town patients. Roentgen radiation for thin, ptotic women, aged thirty-two to forty. Radium or hormones for fat women. Complete artificial menopause for women forty-two or over. Roentgen radiation for young women, giving small doses after each period until improved.

Leda J. Stacy: Favors radium if curettage is done, roentgen radiation if not. Thinks there is less unfavorable after-effect following roentgen irradiation.

Sanford Withers: Favors radium because it may be done at the same time as curettage and the frequently accompanying cervicitis may also be benefited by its application.

Summarizing these opinions, we find two favor radium, two favor a combination of roentgen radiation and radium and six favor roentgen radiation except under circumstances and in patients where it is obviously desirable to use radium.

With the use of radium more rapid results are secured and it is very convenient to apply at the time of a diagnostic curettage. There is a combined effect on the endometrium and ovary that is at times desirable. It is of value in clearing up cervicitis when it is present. It has a dramatic appeal to the patient. On the other hand, it distinctly is not desirable when associated pelvic pathology is present and it may result in a slough of the endometrium that offers an excellent portal of entry to operative infection. With the use of radium it is necessary to hospitalize the patient. There is more time lost by the patient from her work and the total cost of her illness is greater.

The roentgen ray as ordinarily employed is slower in its action, and I believe this to be an advantage as the more slowly induced menopause gives rise to less general ill effect. Associated pelvic pathology is no serious contraindication and there is no opportunity for introduced infection. Radiation sickness is reduced to a minimum. Hospitalization is not necessary and the total cost of the illness is less and there is little loss from the daily routine.

The advantages and disadvantages of these two agents about balance. If the more slowly induced menopause is less disadvantageous to the patient from a general standpoint, then the roentgen ray is to be given the preference.

Much of the difference of opinion concerning this question hinges upon the desirability of doing a diagnostic curettage in most of the cases. If this is done there is still no disadvantage incident to choos-

ing the roentgen ray as the agent of choice if malignancy is not encountered. As to the desirability of instituting treatment modified to meet the needs of the malignant case as soon as possible following the diagnostic curettage, I seriously doubt that there would be any considerable difference of opinion concerning the correct diagnosis between the experienced clinician after curettage and the pathologist basing his opinion on quick frozen sections. In the frank case, the gross character of the curettings are frequently indicative of malignancy. In the doubtful case a pathological diagnosis is notoriously difficult for the average pathologist.

In summary, therefore, it seems that there is little to choose between roentgen radiation and radium in the treatment of benign uterine bleeding except for the consideration of those general clinical impressions that roentgen irradiation results in a less objectionable artificial menopause. It is my belief that this alone would justify, in the future, the selection of this type of irradiation for a greater number of patients who present themselves seeking relief from benign uterine hemorrhage.

DISCUSSION

Dr. Henry Schmitz, Chicago. It has been my experience that in the treatment of benign tumors of the uterus the use of the roentgen ray produces better results than radium. The complications in the uterus such as leukorrhea, pyometra, and so forth, following the use of radium are not seen after roentgen therapy. Radium acts directly on the endometrium. The effect on the ovaries with the doses applied is negligible. The ovaries are at least 6 cm. distant from the uterine canal and the ovarian tissue dose attained is less than one-twentieth of the dose at the endometrium. The effect of radium on the endometrium is invariably followed by profuse watery discharges which may last as long as six months. If the uterus is small and the radium capsule large, so the region of the internal os is cauterized, then stenosis of the cervical canal may ensue. Hydrometra and pyometra are disagreeable results but may be overcome by dilatation and rubber drain tubes. Intrauterine surgical manipulations are always risky and may cause a flare-up of old infectious processes causing morbidity and at times mortality. On the other hand, roentgen therapy is free from such complications as leukorrhea, pyometra, morbidity and mortality. The end-results are the same as those obtained from radium. Though hospital expenses may be alike, as diagnostic curettage and biopsy should be done in all cases of uterine bleeding, yet the absence of complications and safety to the patient render roentgen therapy the method of choice.

Dr. Lawrence A. Pomeroy, Cleveland, Ohio. I wish to call Dr. Schmitz' attention to the fact that several years ago from the State Institute for the Study of Malignant Disease at Buffalo, New York, there was a report of a death following roentgen treatment of a carcinoma of the cervix where there was no intrauterine manipulation. Also there was a report in the French literature of a similar death, following roentgen irradiation of a uterine fibroid, where there was no intrauterine manipulation. Both of these deaths were due to peritonitis originating in an old salpingitis.

Dr. H. H. Bowing, Rochester, Minn. I may have misunderstood the essayist. One point brought out in the paper was that the method employed has something to do with controlling the severity of the menopausal phenomena in cases in which a menopausal dose is given. Personally, I have not been impressed with that feature. From my experience, I believe the severity of these phenomena attributable to the patient's individual reaction and not to what the physician does. One cannot say that a small dose will cause little reaction, and an overwhelming dose, a great deal of reaction. The phlegmatic, stable type of woman has little reaction, or if she does, she controls it, whereas the nervous type experiences more menopausal phenomena and shows less tolerance.

Dr. Cathcart (closing). Our usual dose of radium has been 100 mg. in the uterus for fourteen hours, supplemented in most instances by deep roentgen therapy. We have always used 0.5 mm. silver, 1 mm. brass and aluminum filtration. If a patient has hemoglobin of 50 per cent or below and we insert radium, for days afterward she will complain of being tired. If we take the same patient and do a diagnostic, and also a therapeutic, curettage and give her 1,000 c.c. of 5 per cent glucose and saline on two mornings following the curettage she brightens up markedly. We can then start roentgen therapy and she will do well. That has not been my experience with radium therapy.

THE USE OF RADIUM ELEMENT SEEDS IN THE TREATMENT OF CANCER*

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AT A TIME when so many new cancer clinics are being organized in general hospitals throughout the United States, the important problem is presented of determining the quantity and distribution of radium for such clinics. The quantity of radium should be sufficient to care for all cancers seen in the tumor clinic but not in excess of this amount as idle radium is too expensive. The radium may be purchased in such a flexible arrangement that the entire amount can be used interchangeably in the breast, uterus, mouth, skin, etc. The radium may be arranged in such a distribution that additional milligrams may be added to the supply from time to time without disturbing the general scheme, the technique or the type of radium applicators. With this plan in mind, we introduced into the United States the plan of uniform platinum-filtered radium cells, which Sluys of Belgium had first employed. The radium salt is distributed in individual platinum cells, measuring 11.5 mm. in length, 1.0 mm. in external diameter and 0.2 mm. in wall thickness. The radium content of each cell is either 1.33 milligrams (delivering 10 microcuries-destroyed hourly) or 3.33 milligrams (delivering 25 microcuries-destroyed hourly). These platinum cells containing radium may be used without additional filtration on superficial skin lesions or in wax moulages for irradiation of cancer of the lip. Or all the cells may be grouped together in any of the various skin plaques or trays. Furthermore, they may be placed in special applicators for vaginal irradiation or in a bomb for radium therapy of the uterine cervix. The individual cells may be transferred to platinum capsules for esophageal or intrauterine use or for employment in Curie colpostats. If interstitial irradiation is contemplated, the cells may be placed in hollow sheath needles with removable trocar points; these needles are available in various lengths, planned to hold one, two or four cells placed end-to-end. This flexible distribution enables the clinic to obtain the greatest use of a small quantity of radium. Since its first use in the Lendrim Tumor Clinic, this plan has been adopted in more than fifty hospital and private tumor clinics in the United States.

Radium Needles. Interstitial irradiation of large tumors is best accomplished by radium needles, because of the better distribution of radiation than from point sources as radon seeds. In certain regions and organs, e.g., breast, prostate, axilla, thigh, linear foci of radiation by needles are certainly desirable. In many other locations, the need for shorter and smaller interstitial applicators of radium has resulted in the invention of various tiny needles. Carcinomas of the lip, oral commissure, cheek, eyelid, naris, antrum, auditory canal, anus, parotid, metastatic carcinoma in lymph nodes, hemangiomas, etc., in which interstitial irradiation is indicated as a substitute for or supplementary to external irradiation, are better treated by the smallest possible interstitial applicators. The original gold-iridium sheath needle designed to contain a single platinum cell of radium was too long (24.5 mm.) for its internal or radium-bearing length (11.5 mm.). The smallest sheath needle, holding a removable radium cell,

* Read at the Twenty-first Annual Meeting, American Radium Society, Kansas City, Mo. May 11–12, 1936.

is the one described by Treves; it measures 17 mm. in total length. We have found it to be a most serviceable unit. The well-known Cade needle has a permanent radium content and a total length of 16 mm. Charles L. Martin constructed the smallest radium needle we have ever seen in use; it measures 11 mm. in length and is adapted for a radium content of either 0.6 or 1.33 mg. The comparative measurements of these needles are shown in the following table:

	Total Length	Internal Length	External Diameter	Filter
Gold sheath needle (containing radium cell)	24.5 mm.	12.0 mm.	1.9 mm.	0.5 mm. Pt
Treves sheath needle (containing radium cell)	17.0 mm.	12.0 mm.	1.8 mm.	0.5 mm. Pt
Cade radium needle	16.0 mm.	—	1.65 mm.	0.5 mm. Pt
Martin radium needle	11.0 mm.	—	1.6 mm.	0.5 mm. Pt
Radium element seed	7.5 mm.	3.27 mm.	1.2 mm.	0.3 mm. Pt

Radium Element Seeds. Although we have found the sheath needles containing the platinum-filtered radium cells eminently satisfactory in most cases, there are occasional indications for the use of even shorter radium foci. This need was met in times past by the purchase of gold radon seeds. As a substitute, we planned the construction of a radium *element* seed which would constitute a permanent addition to the supply of radium and could be used repeatedly without appreciable loss in strength or value.

This seed is really a tiny tube with an eyelet of smooth bore at one extremity through which the thread for removal is inserted. The dimensions are as follows: overall or external length, 7.50 mm.; active or internal length, 3.27 mm., external diameter, 1.20 mm. The filtration or wall-thickness is 0.3 mm. of platinum (10 per cent iridium-platinum). The filtration value is therefore the same as for the ordinary gold or platinum radon seeds and the tables of dosage computed for the latter are equally applicable in the case of the radium element seeds. The wall thickness is sufficient to filter out most of the beta radiation, so that the emerging beam contains 17 per cent beta rays and 83 per cent gamma rays, which is approximately the same as the quality of radiation emanating from a radon seed.

We have employed eighteen of these element seeds during the past year and have found their constant availability to be an asset of great importance. They are considerably cheaper than radon seeds which must be purchased outright. The small tumor clinic cannot afford a large quantity of radium necessary for an emanation plant, nor can it employ the costly assistance of technicians and physicists for the collection and measurement of such radon seeds. One handicap which is ever present is the necessity for patients remaining in the hospital while the radium element seeds are in place, whereas after the implantation of radon seeds they may frequently return home immediately. On the other hand, there is an advantage in hospitalization during this time because it enables the patient to receive the proper hygienic and dietary management, a factor of considerable value in the treatment of intraoral cancer.

Whenever the radium element seeds are not employed as interstitial applicators, they may be grouped and placed in capsules, plaques, trays or bombs for use in the treatment of cancers of the skin, uterus, etc. Another economy is the fact that only a small initial investment is necessary for a permanent supply of such radium seeds. The present cost of these seeds is approximately $60.00 each.

The radium content of each seed is 1.33 mg. which is sufficient to deliver a dose of

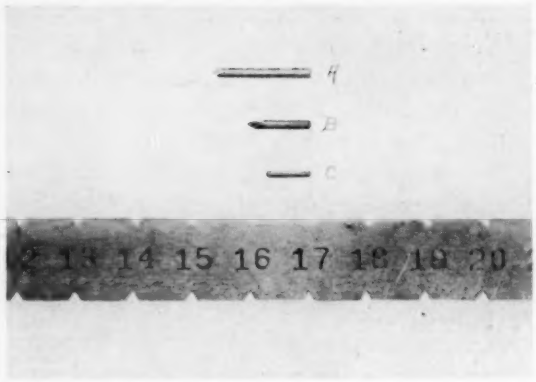

Fig. 1. To show the comparative sizes of, *A*, the Treves single cell sheath needle; *B*, the C. L. Martin radium element needle, and *C*, the new radium element seed.

10 microcuries-destroyed hourly. Therefore in 100 hours (or slightly more than four days) each seed would deliver a dose of 1,000 microcuries-destroyed or 1 millicurie-destroyed. This dose is the average one employed for each seed. The intensity of such interstitial irradiation is constant during the time when the element seeds are in place; it does not diminish exponentially as does the decaying radon seed. Advantage is taken of this fact by giving protracted yet continuous interstitial irradiation of constant intensity in some tumors. By withdrawing and reinserting the same radium element seeds in different foci of the tumor while maintaining the proper distribution throughout, it is possible to prolong the constant interstitial irradiation over a period as long as three weeks, in this way reproducing an effect which Coutard has accomplished so well with roentgen rays.

The trocar needles for the insertion of these seeds are of slightly larger bore (1.8 mm. external diameter) than the usual needles for gold radon seeds. Each needle has a linear crevice or slit extending from the point to the shank, thus permitting the attached thread to be without the needle, while the seed is in the lumen preparatory to its proper deposition (Fig. 2). This measure enables the radium therapist to deposit the seed and withdraw the implanting trocar needle without traction on the thread and possible dislodgment of the seed. According to Withers, the slit trocar needle originated with C. F. Whittemore. The point of emergence of the threads from the tissue affords an accurate localization of each seed. The thread which we have found most satisfactory is the Deknatel suture.

There are some undeniable handicaps in the use of these radium element seeds. They are slightly larger than the gold radon seeds, yet as far as ease of insertion is concerned, they can be used anywhere that a gold radon seed can be employed. They must be guarded carefully and the patient inspected frequently while they are in use because of the chance of their loss and the possible danger of losing them in the tumor. This danger is conceivably no greater than for small radium needles. We have never inserted these radium element seeds in intra-abdominal tumors nor in such a location as a high inoperable carcinoma of the rectum for fear that their possible loss would necessitate a serious operation for removal. To date we have never failed satisfactorily to withdraw all seeds from tumors treated. We make no prediction concerning the extension of their future application, but at the present time we make use of them only in superficial and accessible tumors. We believe that they are satisfactory interstitial radium applicators for certain carcinomas of

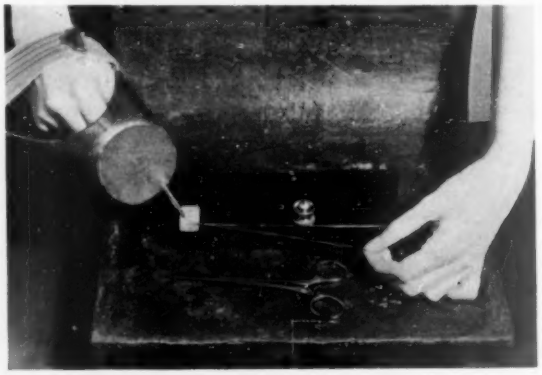

Fig. 2. Placement of radium element seed in slit trocar needle preparatory to implantation. The thread projects through the crevice in the needle which is too narrow to permit escape of the seed. The near hand is protected by the usual lead shield.

the lip, oral commissure, cheek, eyelid, naris, antrum, auditory canal, anus, parotid, skin, metastatic carcinoma in lymph nodes and in some benign tumors, e.g., hemangioma.

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DISCUSSION

Dr. Charles L. Martin, Dallas, Texas. Dr. Pack's radium seed will, no doubt, have its uses. I understood him to say that he thought it superior to the small needle in certain cases and I hope he will tell us just what these cases are, in closing.

Our needle can be planted without a trocar and has more complete filtration. However, I believe the chief advantage of the needle is the accuracy with which it can be planted. When proper lengths are selected and the implantation is done in parallel rows even radiation is assured. After the small seeds are buried in the tissues their exact location is a matter of conjecture.

Our patients with intraoral implantations are allowed to take food, and it seems to me that the small seeds might easily be dislodged during mastication. However, they furnish an economical type of applicator for the radiologist who finds it difficult to obtain radon and they will, undoubtedly, prove of great value.

Dr. William E. Costlow, Los Angeles, Calif. As to this new needle or tube, six or seven years ago my partner, Dr. Meland, had an idea similar to this and we had very small platinum needles made which we used for some time. As I remember, they were practically the same size as the ones Dr. Pack describes. We had some difficulty in getting radon seeds on the Pacific Coast, and felt that small needles would take their place. We had some trouble in keeping our small platinum applicators in place and in knowing where we had placed them after removing the trocar which was necessary for their insertion. Often the attached string would cause the small applicator to be slightly misplaced when the trocar was removed. Consequently, for several years we have not used them. We have been using needles similar to Dr. Martin's and feel, as he does, that we can be more certain as to the location of the radium in respect to the tumor, by using the longer needles. I realize that Dr. Pack's idea was to recommend the use of these small tubes in localities where radon implants are difficult to obtain, but I still think there are some difficulties in connection with them.

Dr. Pack (closing). The applicator we have described is not a needle as has been inferred in the discussion, but a small tube in miniature. It is inserted into tumors through trocar needles in a manner similar to the introduction of gold radon seeds. Radon seeds are more universally applicable and somewhat safer, it is true, but the element seeds are not intended to supplant radon seeds in clinics where emanation plants for their manufacture are established.

We have used these tiny seeds in carcinomas of the lip, tongue, anus, auditory canal, etc., and in lymph nodes containing metastatic carcinoma and are convinced of their practical usefulness in the small tumor clinic functioning in a general hospital. In reply to the cautionary comment that the threads attached to these seeds in oral cancers may be bitten through during mastication, we may say that patients are fed liquid food and only through nasal catheters for the four days during the treatment.

I doubt if there has been any smaller interstitial applicator of radium element to date. A radium needle or a radium cell in a sheath needle is longer because of the inactive point. We have radium needles and employ them constantly in certain locations. The previously described radium element seeds are, however, a worth while addition to the armamentarium of the tumor clinic.

COMPARISON OF THE EFFECT OF VARIOUS FILTERS IN THE 500 KV. RANGE*

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I. GENERAL THEORY

THERE are several well-known facts that should be kept in mind in considering the effect of various filters upon the quality of the roentgen-ray beam. First, it must be remembered that the sole function of a filter is to remove something from the beam. Unless it is a faulty filter it never adds anything, and in any case it cannot add anything desirable, but rather something detrimental. There are, however, limits beyond which this process of removal should not be carried; in other words, a filter ceases to be useful when it takes out a considerable part of the radiation desired.

Materials which may be used as filters are characterized by an absorption coefficient which is a measure of the ability of the material to absorb roentgen rays of a given wave length. Figure 1 shows a group of curves for the absorption coefficients of lead, tin, copper, iron, and aluminum in the voltage range in which we are interested. It will be seen at once that at the extreme high voltage end the mass absorption coefficients for all of these metals are practically the same. As we come down the voltage scale to 500 kv., we find that the coefficient for lead is about twice as large as the coefficient for any of the other four metals, and coming farther down to the 400 kv. band we find a still greater difference. At this point the coefficient for lead is about twice as great as that for tin, and approximately three times as great as that

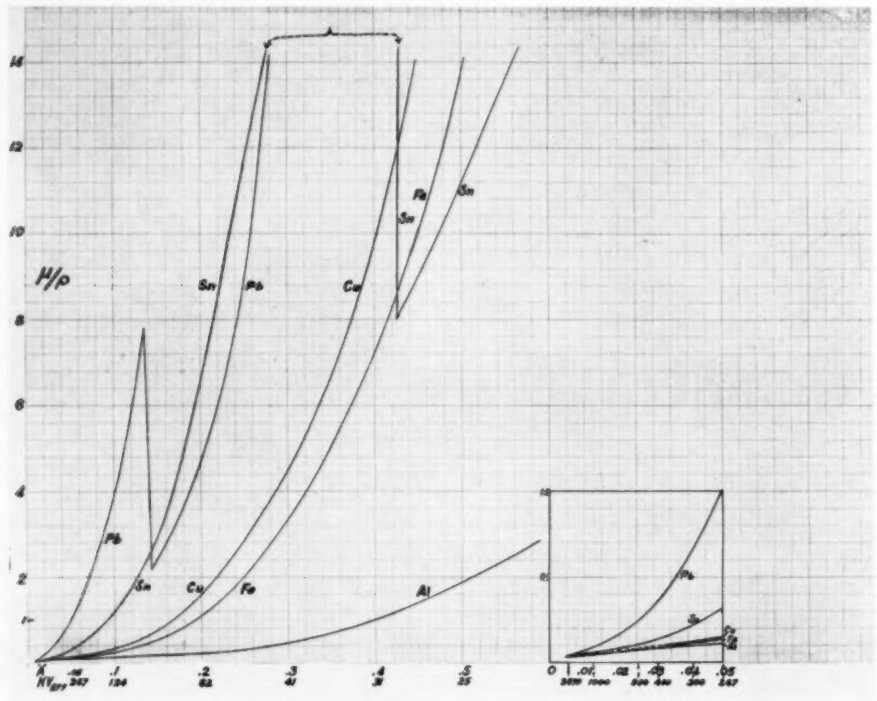

Fig. 1. Absorption coefficients of four metals.

* Read at the Thirty-sixth Annual Meeting, American Roentgen Ray Society, Atlantic City, N. J., Sept. 24–27, 1935.

for the other three metals. It is to be remembered that the absorption coefficient is not a simple factor, but an exponent. Hence when the coefficient is doubled, the base is squared and the difference in actual absorption of the roentgen beam is greatly increased.

The absorption equation is: $I = I_0 e^{-\mu/\rho \cdot \rho\chi}$ where I_0 is the original intensity; e, the base of the natural logarithms, having the value 2.718; μ/ρ is the absorption coefficient divided by the density, or the "mass absorption coefficient," and is the constant in which we are directly interested in this discussion; and $\rho\chi$ is a constant depending upon the thickness and density of the filter. If for the purpose of a quick demonstration we let $e = 3$ and assume a filter such that $\rho\chi = 10$, then we find on the curve of μ/ρ for lead at 500 kv. the value 0.2. This means that after passing through this filter the original intensity will be divided by e^2, or that the filter will transmit 1/9 of the amount of roentgen-ray energy of this wave length impinging upon it. Going on to 400 kv. we find the value of μ/ρ about doubled, which means that the original intensity at this point will be divided by e^4 or that the filter will transmit 1/81 part of the energy produced.

With any one of the other metals the change is very much less. It is obvious, then, that in this voltage range the greatest "hardening" of the roentgen beam is obtained with a filter of the heaviest metal, since it transmits most of the short wave energy and cuts off sharply as the wave length is increased. Furthermore, a metal like aluminum which has a very flat curve for μ/ρ will have little effect on the wave length. Rather it will absorb all of the wave lengths in this region equally and to only a relatively small extent. This offers a very fine material for use in the measurement of wave length. In any case, the steepness of the curve of the absorption

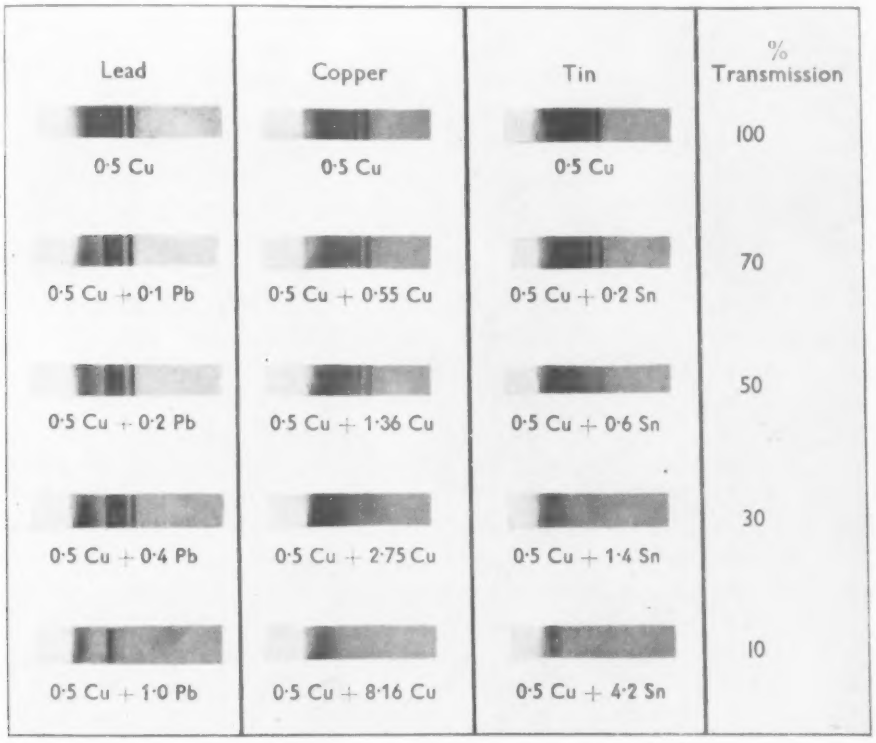

Fig. 2. Transmission bands for lead, copper and tin. (From Mayneord.[1])

coefficient is a measure of the amount of hardening which can be obtained by the use of that particular metal as a filter.

2. Breaks in Absorption Curve

All elements show bands of wave lengths in which they transmit radiation freely. These bands correspond to the characteristic absorption edges of the elements and are so characteristic and so constant that they can be used for chemical identification. When one of these breaks occurs in a wave length region where a tube is being operated for therapy, the filter will have the effect of transmitting two separate bands instead of one. In the lead curve this break occurs at wave length 0.135 to 0.142Å. This is in the strongest band of a tube running between 200 and 100 kv.

There are two physical means of demonstrating this condition. The best demonstration has recently been published by Mayneord[1] (Fig. 2), who photographed the spectrum produced by a tube operating at 250 kv. through filters of lead, tin and copper. The two main points demonstrated are, first, that a thin lead filter has a very marked absorption for the short wave end of the spectrum, which consists of that part of the band which might be therapeutically useful, while it transmits the undesired lines at the long wave end practically unchanged in intensity. There is nothing new about this fact, as exactly the same method has been used for the production of monochromatic roentgen-ray line spectra for many years. Thus a tube with a copper target may be operated at about 35 kv. and with a nickel filter will produce a practically pure line at 1.54Å. With molybdenum target and zirconium filter, a line at 0.7Å may be produced, and so on. Secondly, when the filter has been thickened to the point where its quantitative efficiency has been cut to 10 per cent, the undesired edge still persists, while the short wave end of the spectrum has practically been eliminated. At higher voltages, within the 500 kv. range, this effect is not so marked as it is here, but it still exists to an important degree.

The tin absorption curve also shows an edge and the spectrum again shows a transmission band. It will be noted, however, that this edge appears at a point in the spectrum corresponding to less than 30 kv., where a negligible amount of roentgen-ray energy is produced; and that even here the absorption coefficient for tin is four times as great as the coefficient of lead at its absorption edge.

3. Measurement of Half-Value Layers

Surprisingly enough, there seems to be some question still about the advisability of measuring voltage.[2] However, most of us will still be of the opinion that both the tolerance dose and the depth dose are a function of this important quality. This being the case, we still need an adequate designation of the "quality" of a beam of radiation. As the science and the art of roentgenology have progressed, standards have been set up only to be discarded with further progress.

Only recently an instrument for the direct measurement of high voltages has appeared[3,4,5] and been developed up to the point where it can be considered accurate and reliable up to the 800 kv. range for the measurement of direct and low frequency alternating currents. For most practical purposes, voltage is best designated at the present time as "effective voltage," and this quality is best measured on an absorption curve of an element of low atomic number. The material used for measurement should certainly be of low atomic number for several reasons. In the first place, it is not desirable to have the average wave length of the beam changed appreciably while it is being measured; second, it would be undesirable to use a filter which consisted of a material having a transparent band in the voltage range to be measured; and, finally, the use of an element of high atomic number and high density which would show only a very

small change in thickness for a fairly large change in voltage would give little accuracy.

Probably the best material for the measurement of half-value layers, considering these conditions, is water. This was first proposed by Lauritsen.[6] It has the advantage of meeting all of the requirements stated above and also of being the classical numbers, and this may retard its general adoption. At the same time, it is, in all probability, the most reliable constant for an expression of the quality of a roentgen-ray beam that we have at this time.

4. DEPTH DOSE

There would still be considerable virtue in the establishment of some standard

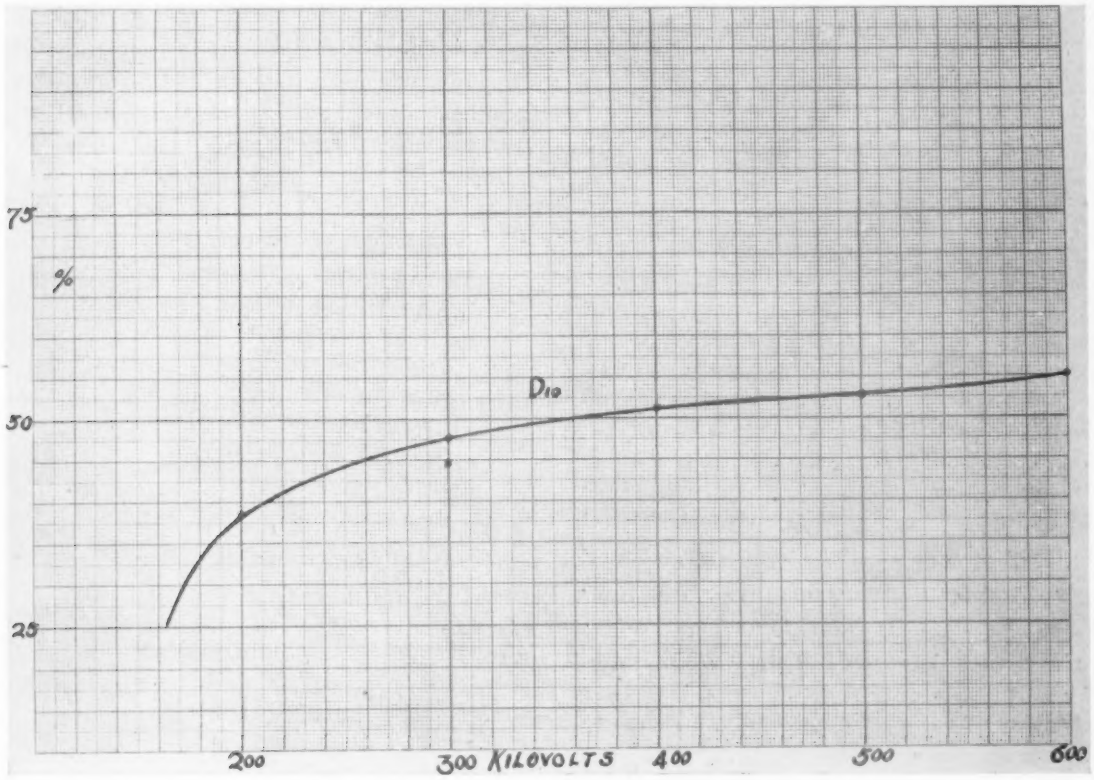

Fig. 3. Variation of depth dose with voltage.

standard in which depth dose is measured. However, water is sometimes rather hard to use, and other materials having similar good properties may be substituted; for example, aluminum. Paraffin, wood, carbon and similar materials have also been proposed on the basis that they are easy to use, reproducible among different experimenters, and meet the requirements set forth.

The effective voltage as a measure of quality has the unfortunate faculty of turning out in rather unimpressively low designation of quality that had a direct physiological significance. The attempts to accomplish this very thing have been too numerous to be mentioned here. One possibility which has occurred to many workers at various times, and was certain to come up for reconsideration in this voltage band, is the direct measurement of depth dose. Unfortunately the depth dose curve flattens out between 200 and 300 kv. and shows no evidence of becoming steep again (Fig. 3). A subsequent increase of 50 kv. causes a change in depth dose which is of

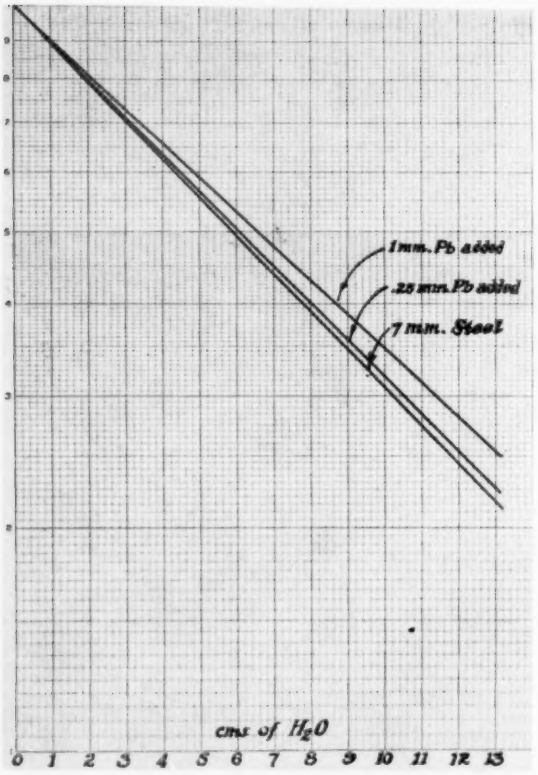

Fig. 4. Absorption in water with added lead filters, showing the half-value layer.

the same order of magnitude as the probable error in the measurement and hence is insignificant as a standard.

It follows that within reasonable limits the change in depth dose with change in filtration will also be small, while the change in the actual quality of the beam may be important. While it is beyond the scope of this paper to discuss them, two further facts must be remembered in this connection: first, that the present method of measuring depth dose, while it will undoubtedly be retained as a practical method, is open to criticism; and second, that depth dose may not be the only physical variable of great biological importance with increasing voltage. This being the case, it follows that we must consider the possible filter material with the intention of choosing the material or the combination of materials which will give the hardest possible radiation for the best tube efficiency. It is obvious that any system of filters which necessitates the use of long treatment time or the operation of the tube at more than a safe current should not be used.

5. Practical Filter Considerations

In considering filters for practical use, one further discrepancy in measurements must be remembered. When a half-value layer is taken in either water or aluminum, the technique is such that general scattering from the filters is carefully eliminated at the ionization chamber. On the other hand, when depth dose is measured, the small chamber is in intimate contact with the material so that the greatest possible amount of scattering is effective on the chamber. Since the scattering effects vary widely with wave length, it is possible that a combination of wave lengths may be encountered which will give very different results when investigated in this manner. Such a variation is a useful accident, however, as it clearly demonstrates the difference between good or ineffectual filters.

This state of affairs is demonstrated by the following two illustrations (Fig. 4). With the tube operating at 550 kv. the half-value layer was measured in water using 7 mm. steel as a primary filter. The layer is a fraction more than 5.9 cm. of water, corresponding to an effective voltage of 300 kv. With the addition of 0.25 mm. lead the half-value layer rises to slightly more than 6 cm. of water. When the lead filter is increased to 1 mm., the half-value layer goes up to 6.6 cm., increasing the effective voltage reading to 400 kv. This appears to be a very desirable improvement, but let us consider what has happened to the depth dose and surface dosage rate while this change was in progress (Fig. 5). At 550 kv. constant potential, with 7 mm. steel filter, the depth dose measured in rice is 53 per cent with a 20×20 cm. field, and 47 per cent with a 10×10 cm. field. In the series of experiments shown, certain restrictions were imposed by the use of the filters and other apparatus available and the field size was chosen at about 15 cm. square. At this field size D10 was found to be about 51 per

cent. Thin lead filters 0.2 mm. in thickness were then interposed in the beam remote from the surface of the rice which was always protected from possible fluorescent radiation with a 1 mm. aluminum filter. Under these conditions the depth dose first made a small but definite decline. When 0.75 mm. of lead had been added the depth dose rose to about 50 per cent while the surface dose dropped to the same value. Further additions of lead filter to a total of 2.5 mm. brought the surface intensity down to 18.5 per cent of the original but brought the depth dose no higher than 50 per cent, this same point having been reached at 0.9 mm. of lead when the surface dose was still 45 per cent of the original.

A similar series was run using filters of pure tin in 0.5 mm. increments. This curve is not shown as there was no measurable effect on the depth dose. The attenuation of the beam per millimeter is of course less than that obtained with lead.

Since the purpose of these experiments was to find a filter which would improve the output of the tube with respect to those qualities considered important in therapy, the next logical step was to test composite filters. In every case the steel filters were left in situ. Various combinations were then added and the beam tested for any change in quality. Since copper offers no advantage over iron in this range, and since it had already been demonstrated that no additional iron (or copper) filters were required, no further tests were made on these elements. These eliminations together with the lead and tin series already cited narrowed the field of possibilities to combinations of lead and tin.

As a first approximation, a combination of 0.25 mm. Pb and 0.10 mm. Sn was tried at 475 kv. As might have been predicted, the depth dose definitely dropped a small but measurable quantity, from 49 per cent to 47 per cent. The series was continued until this combination reached a thickness of 1 mm. lead plus 0.50 mm. tin. At this point the depth dose had definitely risen to 51.5 per cent, but at the same time the

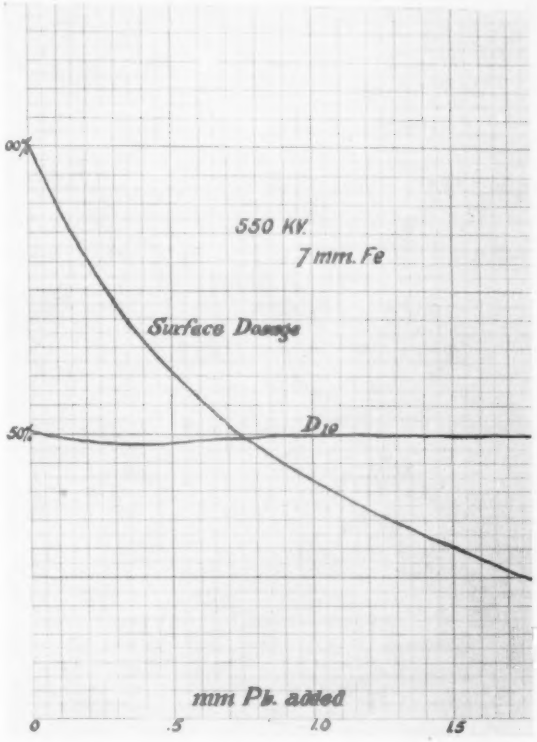

Fig. 5. Change of surface dose and depth dose with added lead filters.

surface dosage had dropped to 26 per cent. In other words, this combination of filters gave a definitely improved quality of radiation for physical measurements at this voltage, but would require four times the milliamperage for the same type of therapy.

The measurements at 550 kv. follow the same general trend. A thin lead filter backed up with only a thin tin filter shows a slight decrease in depth dose, due to the fact that neither filter is sufficiently thick to remove what remains of the characteristic transmission band of the other. When the thickness of the lead is greatly increased, little or no improvement in depth dose results, while the attenuation of the beam becomes too great for practical purposes. At this higher voltage, the efficacy of the steel for removing the characteristic transmission of the lead is enhanced on a percentage basis of the total radiation, and hence the effect of a tin backing filter on the lead is less marked. By way of illustration we can take a combination of 1 mm.

lead with 0.50 mm. tin. With the same size field and the same conditions as stated above, and no added filter, we obtain a 50 per cent depth dose at 550 kv. With the combination of one lead and one-half tin added we still get a 50 per cent depth dose, but the surface dosage on the rice phantom has decreased from 31.4 r/min. to 10.37 r/min., a decrease in tube efficiency of 67 per cent.

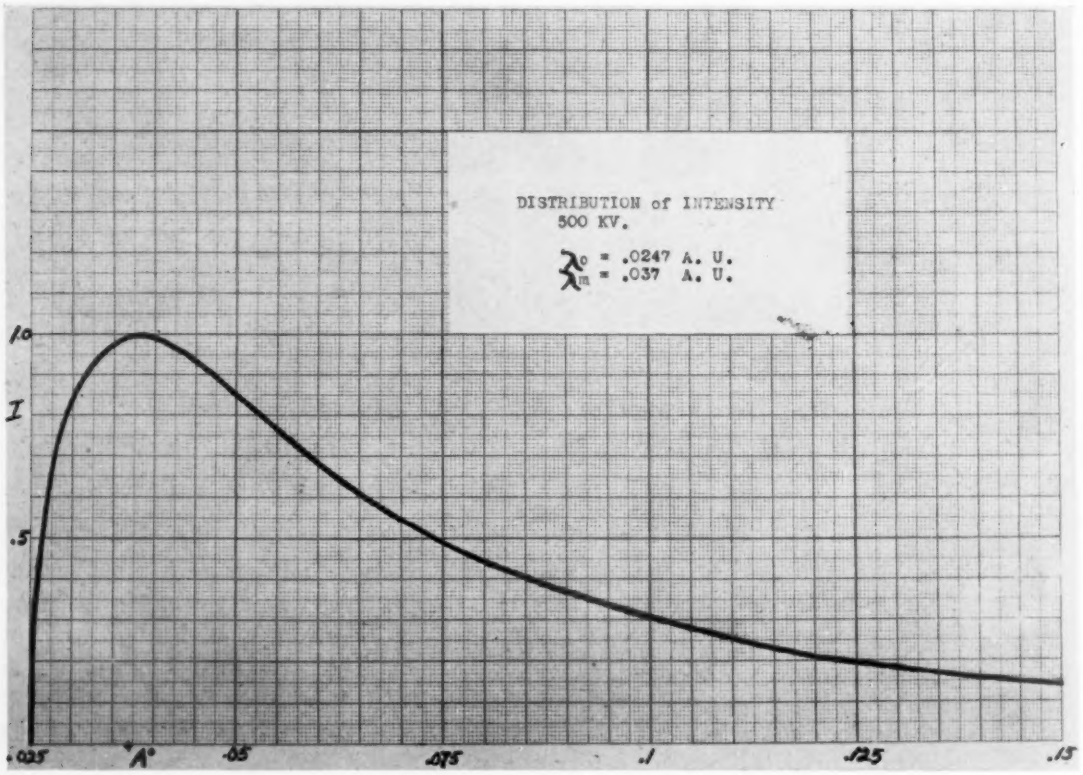

Fig. 6. Spectral distribution of intensity at 500 kv.

If now we consider the spectra produced by tubes operating in this voltage range, and the effect of heavy filters on these spectra, the experimental results obtained will seem more logical than they do when merely tabulated. For example, Figure 6 is an emission spectrum for a tube operating at 500 kv. The high voltage end of the spectrum begins at the short wave limit which for this voltage is 0.0247 Å. From this point it rises steeply to a maximum value at about 0.037 Å, corresponding to 300 kv. and slopes away more gradually toward the long wave end. The next (Fig. 7) shows this same emission curve with the transmission curves resulting from the introduction of two superimposed lead filters. We see at a glance from this curve that the thin lead filter has removed about 15 per cent of the intensity of the strongest band, and increasingly greater amounts of the softer radiation following this point. When we reach the band of the characteristic transmission for lead we find that the filter has removed only about one-third of this radiation.

If we follow the same process to a somewhat lower voltage, we find the same thing happening to a more marked degree (Fig. 8). Here the lead filter has hardened the short wave end of the spectrum more sharply, but since the curve does not fall away as rapidly as before there is a relatively greater amount of energy to be transmitted in the transparent region. This, then, would give the effect of exposing the patient to two separate roentgen treatments, one with a highly filtered beam

and one with a 100 kv. tube at the same time. At 300 kv. this effect is so easily detectable, as has been demonstrated by several workers, that it is not dangerous. If ignored, however, it would in all probability have undesirable results.

At somewhat higher voltages the effect is less marked, but still demonstrable. The most probable explanation of the small discrepancy between half-value layer and depth dose is that when the output of the tube is filtered by lead alone the emergent beam consists of two separate components. In measuring the half-value layer the soft component, which consists of the characteristic transmission band for lead, is filtered out in the first thin layer of the measuring filter and has little effect on the reading. In exactly the same manner this soft component is absorbed in the surface layer of the phantom, giving rise to a large amount of scattered radiation and hence cutting down the percentage depth dose.

We can conclude then from these data that within the 500 kv. range, by which we mean to include voltages from 300 kv. constant potential to 800 kv. of unbiased alternating current, the following findings should hold true:

That the use of lead filters is to be considered with a certain amount of caution.

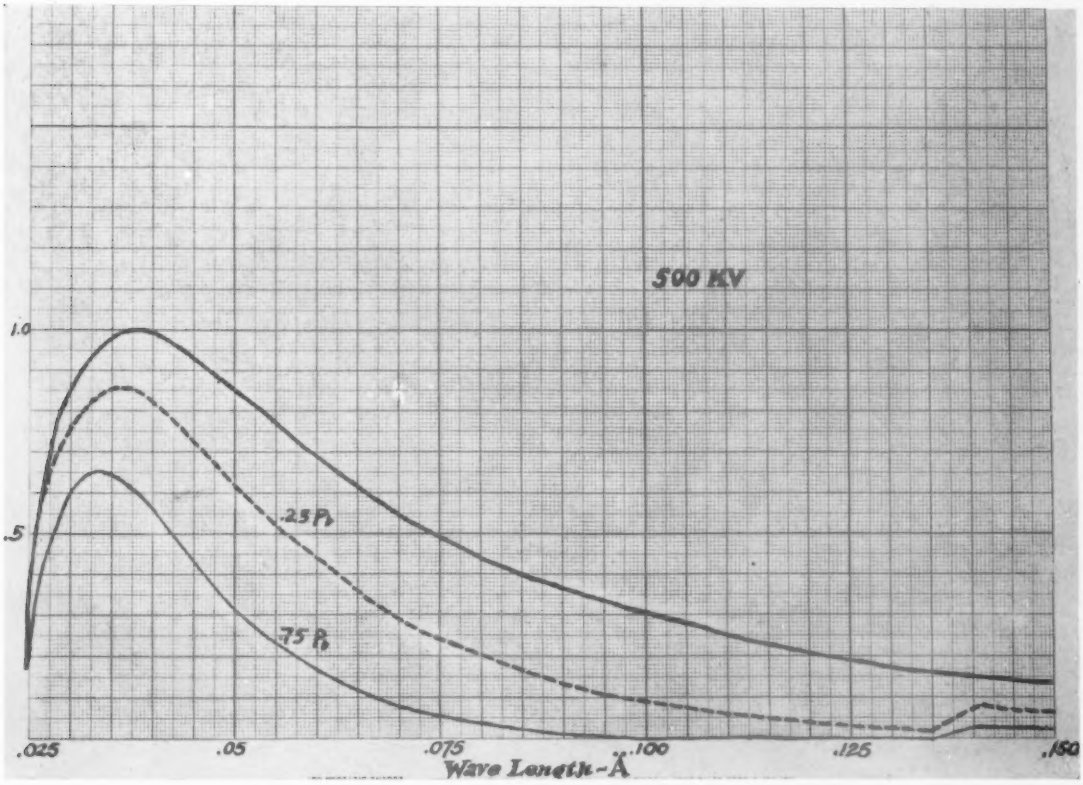

Fig. 7. Change in spectral distribution caused by filters.

That lead filters are not to be considered unless backed by a sufficient amount of tin, or some similar material which will absorb their characteristic transmission.

That any filter material, whether lead or something else, is only effective in hardening the emergent beam up to a certain critical thickness, and that further addition of filter merely serves to decrease the efficiency of the tube.

That a satisfactory filter from the point of view of depth dose and tube efficiency can be made for use in this voltage range, of relatively light metal such as iron or copper, while tin appears to be the best possibility of all.

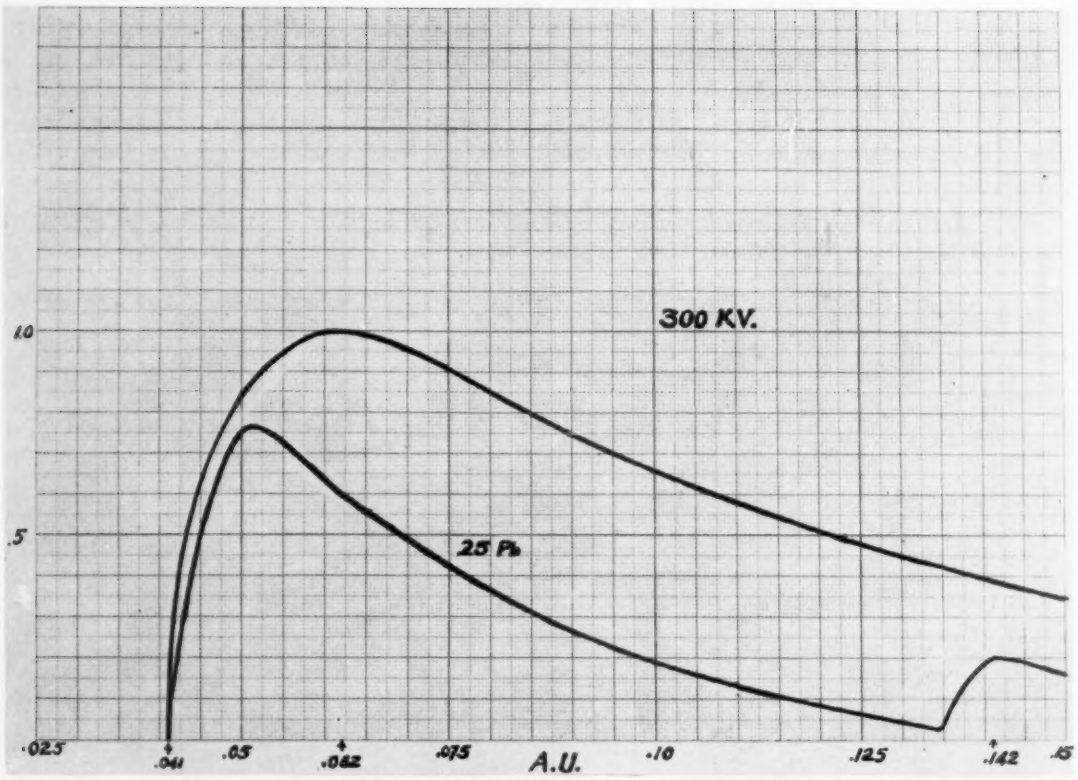

Fig. 8. Spectral distribution of intensities at 300 kv. with no filter and with an added lead filter.

Above the constant potential range specified, or with an alternating current tube running with a heavy bias, undoubtedly lead backed with tin offers the best possibility of the metals under consideration.

Within this range, depth dose alone is not a satisfactory criterion of radiation quality, since the change in depth dose is very small.

The evidence so far gathered would lead us to believe that relatively little change in depth dose is to be expected with increasing voltage above 500 kv. constant, unless such a tremendous increase in voltage can be made that the mechanism of absorption is definitely modified.

The valuable assistance given by Drs. Hayden and Cassen in the preparation of this paper is gratefully acknowledged.

Addendum. It should be noted that all data taken from the experiments recorded in this paper were obtained during the early part of 1935 on a beam of radiation from our high voltage tube, *emergent at an angle of 90° from the tube axis.* Since that time it has been shown that a difference in quality exists between a portal situated at 90° and one taking its beam from the tube at some other angle with respect to the axis of the cathode beam. A paper on this subject by Dr. Cassen and myself was read at Cleveland which contained a complete analysis. This will appear in a future number of this Journal.

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FACTORS INFLUENCING THE QUANTITATIVE MEASUREMENT OF THE ROENTGEN-RAY ABSORPTION OF TOOTH SLABS*

VIII. EMULSION FACTORS

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A. IMAGE SHARPNESS

EARLY in our contemplation of the variables which might influence the results of a roentgen densitometric analysis of biological materials was the consideration of the part played by the photographic emulsion, namely, its influence upon image sharpness and the filtration effect, to mention two major properties to be discussed in this section in some detail. This is, in a sense, also a testing of the resolution both of the film and of the densitometer.

There are a number of factors which might cause a fuzziness of the edge of an image. Among the more important factors are the penumbra effect due to the finite size of the focal spot of the tube target, the finite thickness of the materials under examination, and the finite thickness of the two emulsions, the film base, and the paper cassette. The net result of these factors may be tested by measuring the sharpness of the image of the edge of the step tablet.

To test the sharpness of the image in our roentgenograms, a number of films were sent to Dr. L. A. Jones (Eastman Kodak Research Laboratory) who studied them with the aid of an automatic recording microphotometer. A section of some of the tracings which were obtained are included. The roentgenogram was made upon "dupli-tized x-ray film" at 30 kv., 30 ma., 30 inches, 6 sec., no tube-stand filter, black paper-wrapped film, on which had been laid the aluminum penetrometer and tooth slab No. 1.

Our principle interest was in determining whether or not there was a gradual change from the density on each side of the enamel (or aluminum filter) to the highly contrasting area under the enamel (or filter). To illustrate the density changes formed, the tracing of the recording microdensitometer is given (Fig. 102) across the film including Step 5 (approximately equivalent to 1 mm. thick dentine in absorption).

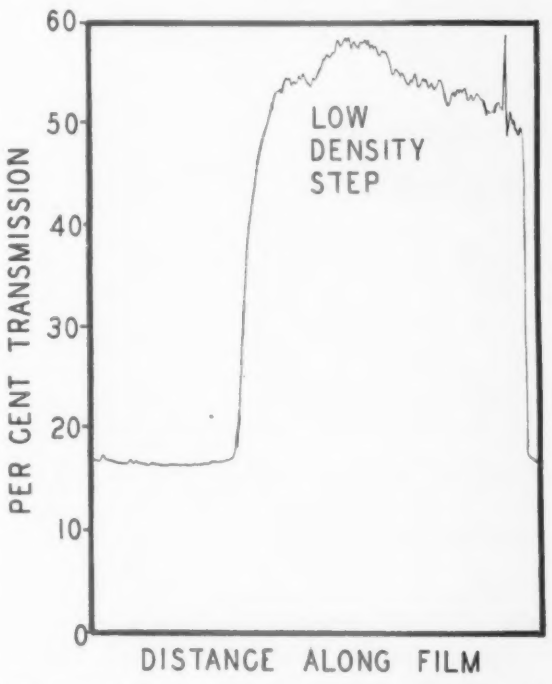

FIG. 102. The tracing of the recording microdensitometer (courtesy of L. A. Jones, Eastman Kodak Company) across a low density step. The vertical nature of the tracings between the lower horizontal line (black film not under penetrometer) and the upper horizontal line (Step 5 of the Al penetrometer) indicates a satisfactory image sharpness.

Thus it may be seen that the image

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sharpness required for a quantitative study is demonstrated under the conditions of our method (within the limits of a precision recording microdensitometer).

B. EMULSION THICKNESS

In studying the density gradients discussed under Focus (see paper II, part A) before the gradients were ascribed to the well-known field gradients (Duane, Coolidge, etc.), it occurred to us that the effect might be due to a gradient in the thickness of the emulsion. Thus if the emulsion became progressively thicker from edge to edge of a 5″×7″ film, a uniform exposure would lead to a progressively greater density in the thicker regions. In order to test this hypothesis, sections were made using standard technique of a film having a marked density gradient. Measurements were then made of the emulsion thickness with a filar micrometer ocular at a magnification of approximately 70×. The readings (from the filar, not microns) are recorded in Table LXXXIX. The distance along the film is such as to cover most of the width of the step (Step 8, the least dense) in the measurements. The penetrometer being 15 mm. across, the measurements are made at intervals of about 1.5 mm. The series of measurements show a somewhat poor ability to obtain a duplication of the exact place along the film, and to make the same measurement, a not unexpected result. However, the totals show no tendency to vary regularly from one edge to the other and it was concluded that film thickness changes were not responsible for the density gradient. The experimentation consequently was directed toward field gradients of the beam of radiation (paper II).

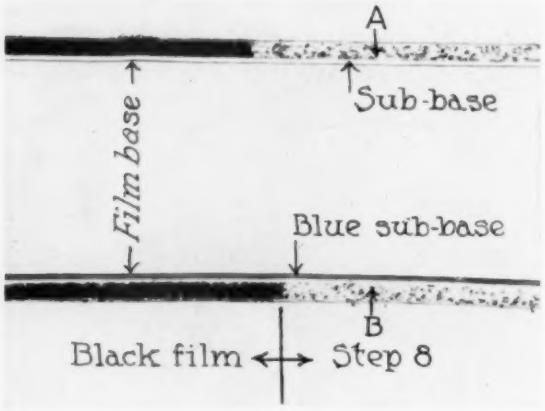


FIG. 103. A photomicrograph (original enlargement 250×) of a section across the least dense step of the penetrometer on "dupli-tized x-ray film." Emulsion A contains more developed grams than emulsion B. Note relative thickness of emulsions, sub-bases and film base. The sub-base under emulsion B contains a dye to give the film a blue tint for diagnostic clarity.

We were interested in the relative thickness of the film base and "sub-bases." Because many of those whom we consulted, even when technically interested in roent-

TABLE LXXXIX

Location Along Film	Filar Micrometer Readings					
	Series I			Series II		
	Left	Right	Total	Left	Right	Total
1	77	57	134	94	48	142
2	30	63	93	77	52	129
3	5	51	56	8	53	61
4	16	52	68	6	53	59
5	76	55	131	25	51	76
6	30	53	83	41	55	96
7	11	56	67	65	56	121
8	35	53	88	4	56	60
9	26	54	80	94	56	128
10	9	55	66	77	59	136

genographic work, were surprised by the relative thicknesses of the parts of the roentgenographic film, we are including a photomicrograph of a section of "duplitized x-ray film" (Fig. 103). The enlargement is probably 250×. The section is photographed at the junction of the image of the thickest step of the penetrometer (least dense photographically), and the dark film exposed to unfiltered radiation. There are apparently more developed grains in the emulsion layer "A" than in "B," explicable by supposing that "A" was on the upper side when roentgenographed. Further, the margins of the step tablet image in the two emulsions are not at the same "longitude" which may be attributed either to the penumbra effect of a broad focal spot, or to a displacement of the tube above the penetrometer to one side. The film base is perfectly transparent as is the upper "sub-base" under emulsion "A." However, the "sub-base" under "B" appears grey in the photomicrograph, although it was *blue* in the original (dyed to give the blue tint for diagnostic clarity).

In conclusion it may be said that neither the emulsion nor the base varies in thickness sufficiently to cause density gradients within our limits.

C. FILTRATION EFFECT OF EMULSION

In Table XCI are given the average D.Rs. in the various steps of the penetrometers in 15 superimposed films taken at 30 kv., 30 ma., 30 inches, no tube stand filter, one black paper wrapper around the whole bundle of 15 films and at 10 seconds' exposure. This should indicate the character of the filtration effect of the emulsion, and show the effect, if any, it might have upon the I.Vs. The D-T curves are logarithmic, similar and of decreasing ordinates and slopes with decreasing level in the laminated filter of film bases and emulsions. The D.Rs. under a given step do not decrease regularly with the decreasing level due probably to differences in the total emulsion thickness on the two sides of the several films; a slightly thicker emulsion of course giving a slightly increased density. The D.Rs. under Step 3 (Fig. 104) illustrate the magnitude of irregularity attributed to emulsion differences. These differences are also shown in the D.Rs. under the enamel and the dentine (Table XCI) which are also plotted against the film level (1 being top) in Figure 104. The difficulty of reading exactly the same tooth area in the several films produces a more marked irregularity. The I.Vs. for the enamel and for the dentine in terms of mm. Al (Table XCI) when plotted against the film level (Fig. 105) show for the enamel a skew line lying above the average I.V. (1.10 mm. Al) for the topmost 7 films and below for the bottom-most 8 films while for the dentine the I.Vs. are fairly randomly distributed about the average (0.77 mm. Al). The explanation for this difference between the I.Vs. for enamel and for dentine lies in the fact that the "white" roentgen-ray beam is changed in

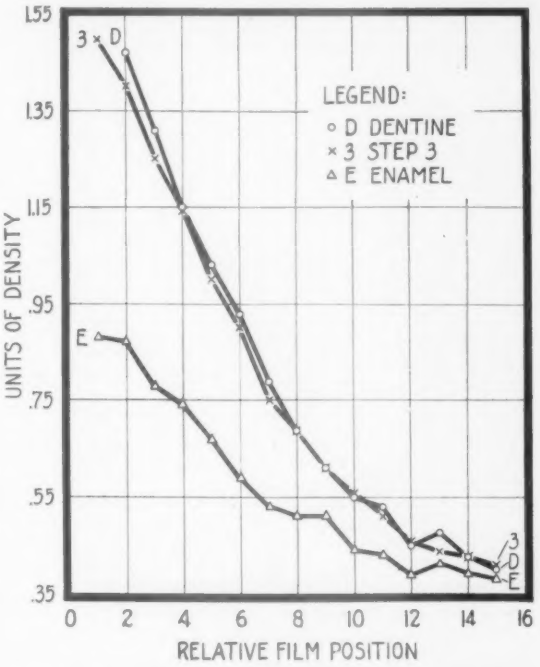


Fig. 104. The D.Rs. in Step 3 and in the enamel and dentine are plotted against the relative film position (No. 1 being topmost) in an exposure of 15 superimposed films. Note the slight irregularities due to slight differences in total emulsion thicknesses.

TABLE XCI

15 SUPERIMPOSED FILMS, 30 KV., 30 MA., 30 INCHES, 10 SECONDS, NO TUBE STAND FILTER, BLACK PAPER-WRAPPED FILM

Film	12234	12235	12236	12232	12231	12233	12238	12238
Densit. Read.								
Step								
1	2.8+	2.51	2.22	2.01	1.83	1.64	1.35	1.27
2	2.08	1.86	1.62	1.48	1.34	1.20	0.98	0.92
3	1.50	1.40	1.25	1.14	1.00	0.90	0.75	0.69
4	1.17	1.07	0.94	0.88	0.78	0.71	0.58	0.53
5	0.91	0.82	0.74	0.66	0.60	0.55	0.49	0.45
6	0.70	0.61	0.58	0.54	0.50	0.44	0.42	0.41
7	0.56	0.49	0.47	0.45	0.42	0.38	0.36	0.35
8	0.45	0.43	0.42	0.40	0.37	0.35	0.33	0.33
Enamel	0.88	0.87	0.78	0.74	0.67	0.59	0.53	0.51
Dentine	1.61	1.48	1.31	1.15	1.03	0.93	0.79	0.69
Interp. Val.								
Enamel	1.27	1.20	1.20	1.16	1.16	1.19	1.14	1.09
Dentine	0.73	0.75	0.74	0.78	0.77	0.76	0.74	0.79
Step 1 diff. from 1 film to next (Upper-under)			.29	.21	.18	.19	.29	.08

Film	12239	122311	122310	122312	122315	122314	122313
Densit. Read.							
Step							
1	1.08	1.00	0.88	0.74	0.67	0.63	0.55
2	0.77	0.73	0.66	0.55	0.53	0.49	0.46
3	0.61	0.56	0.51	0.46	0.44	0.43	0.41
4	0.48	0.46	0.45	0.39	0.39	0.39	0.36
5	0.42	0.40	0.40	0.35	0.35	0.35	0.34
6	0.39	0.35	0.36	0.35	0.32	0.32	0.33
7	0.33	0.33	0.33	0.29	0.31	0.31	0.31
8	0.33	0.30	0.30	0.27	0.31	0.30	0.31
Enamel	0.51	0.44	0.43	0.39	0.41	0.39	0.38
Dentine	0.61	0.55	0.53	0.45	0.48	0.43	0.40
Interp. Val.							
Enamel	0.96	1.06	1.12	1.06	0.92	1.00	0.93
Dentine	0.77	0.83	0.77	0.82	0.70	0.78	0.83
Step 1 diff. from 1 film to next (Upper-under)	.19	.08	.12	.14	.07	.04	.08

quality as it passes through film after film, the longer wave length components being removed more rapidly than the shorter. In effect, therefore, the lower films receive a beam not only lessened in intensity due to the absorption of the films above but also lessened in "effective" wave length. If the spectral coefficient of two substances are the same, then they will absorb equal fractions of an incident intensity of radiation regardless of its quality (paper v) but if the absorption coefficients are different then

Table XCII

GROUPED FILMS, AVERAGE INTERPOLATED VALUES FOR ENAMEL AND FOR DENTINE

Gen. Av.	Average			Percentage Change		
	Top 5	Mid 5	Bottom 5	Top-Mid	Mid-Bottom	Top-Bottom
En. 1.09	1.20	1.09	0.97	10.1	10.9	19.2
Dent. 0.77	0.75	0.78	0.77	4.0	1.3	2.7

different fractions of the incident intensity will be absorbed depending on the quality of the incident radiation. Dentine has approximately the same absorption coefficient as Al; on the other hand, enamel has quite different absorption coefficients. Thus, the absorption of dentine relative to Al (the interpolated value) will not change and does not change even though the beam striking the lower films is greatly changed in quality from the beam striking the upper films, whereas enamel whose absorption coefficient is not the same as Al will change relative to Al (I.V.) as seen in Figure 105 (see paper v).

In order to make sure that these conclusions, are true, the data will be considered briefly from the statistical point of view. The general averages for all the I.Vs. for enamel and for dentine (see Table XCII) are 1.09 mm. Al and 0.77 mm. Al, respectively. By grouping the I.Vs. for enamel and for dentine in 3 groups composed of the top five, the middle five and the bottom five films, average values of 1.20, 1.09, and 0.97 mm. of Al are found for the enamel, and average value 0.75, 0.78, and 0.77 mm. Al are found for the dentine. In the enamel, these averages represent a decrease of 10 per cent from top to middle, of 10 per cent from the middle to bottom, and of 20 per cent from top to bottom five films. This is strong evidence that the line for enamel I.Vs. is really skewed since the differences top-to-middle and middle-to-bottom groups are at least twice our method error. On the other hand, in the dentine, the averages represent an increase of 4 per cent from top to middle, a decrease of 1 per cent from middle to bottom, and an increase of 3 per cent from top to bottom five films. Since all the changes are

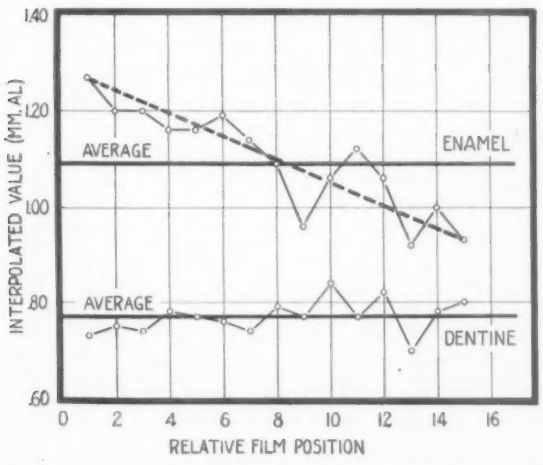


Fig. 105. When the I.Vs. for the enamel and for the dentine are plotted against the relative film position in 15 superimposed films, there is seen to be a constancy of I.Vs. for dentine but a significant decrease in the I.Vs. for enamel with increase of the number of emulsions acting as filters.

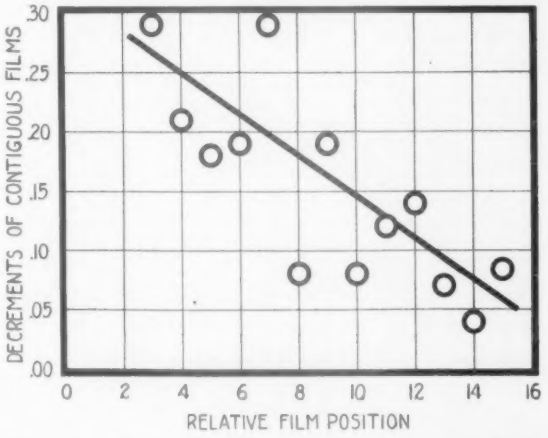


Fig. 106. By subtracting in turn the average D.R. in Step 1 of each film from the D.R. in Step 1 of film immediately above it, the decrement from film to film is found. When this decrement is plotted against the relative film position, a highly irregular decrease in decrement is found.

less than our method error we may plausibly say that the I.Vs. for the dentine do not change significantly from the top to the bottom film.

In figure 106 are plotted the decreases in average D.Rs. in Step 1 between contiguous films (upper-lower) against the film level. The decrements are seen to fall in a highly irregular fashion, nevertheless they suggest the magnitude of the increase in "effective" wave length. There is an average decrement of 0.15 density units per film, and an average absorption of approximately 0.08 density units per emulsion.

It is interesting to compare the filtration effect per emulsion noted above, with the difference between the "a" and "b" film in "radia-tized dental films." The densitometer readings in Step 1 showed an average decrease between upper and lower films of about 0.20 density units, at 30 kv., about 0.15 at 40 kv., and about 0.12 at 50 kv.

In conclusion, a definite filtration effect is demonstrated but it does not change the interpolated values of the dentine since this is dependent upon the near identity of the mass absorption coefficients of the dentine and aluminum (see paper v).

D. DENSITY GRADIENTS

Early observations of the enamel in the photometric field of the Capstaff-Purdy densitometer gave apparent evidence in certain teeth of a peripheral radiopaque zone in the enamel next to the black film; that is, a whiter band seemed to be found in certain portions of certain teeth along the periphery of the enamel. Unfortunately, the maximum width of the white band in any instance was less than a third of the total photometric field (0.5 sq. mm. area); estimations of its density were therefore out of the question. Furthermore, the occasional nature of the white band created a question as to its interpretation, e.i., should the white band be explained in terms of actual radiopaque peripheral enamel, or in terms of an accidental artifact? Thewlis* reported white bands in the roentgenogram of a molar tooth slab, indicating that their occurrence did not include the entire periphery and giving the interpretation that the bands represented bona fide increases in radiopacity. On the other hand, Hollander (private communication) found a similar band in grenz roentgenograms of thin slabs of enamel but also in the peripheral portion of Al sheets of comparable thickness; consequently, Hollander believes the white bands to be artifacts. In a recent paper, Hollander and Saper† have shown conclusively that the white band is really the "Mackie line," a phenomenon long known to photographic physicists.

We were able to take up the quantitative study of the phenomenon by the use of the newly designed densitometer of Bausch and Lomb Company. This microphotometer operates on the general principle (1) of enlarging the photographic image by projection, and then (2) of measuring, by means of a sensitive photoelectric cell, the brightness of the light passing through the various areas of the original film.

The magnification used in our study was approximately 14×; this produces an obvious graininess of the enlarged image but by using a suitable slit, the variations in the deflections such as are obtained with the recording microdensitometer of Dr. L. A. Jones (see Figs. 55 and 102) are smoothed out. By the use of this instrument, we found an apparent "density gradient" in which the density in the various steps *increases* from the more or less uniform central areas toward the black film surrounding the penetrometer. This effect is in opposite sense to the effect known as the "Mackie line" which produces a brighter line in the brighter image next to a dark film area. However, by the measurement of the density gradients in steps of comparable density to that of enamel and the comparison of these gradients to the gradients found in enamel, we were able to show that the peripheral part of the enamel has a greater radiopacity than would arise if enamel were as uniform

* Thewlis. *Brit. Dent. J.*, 1934, *57*, 457.

† Hollander and Saper. *Dent. Cosmos.*, 1935, *77*, 1187.

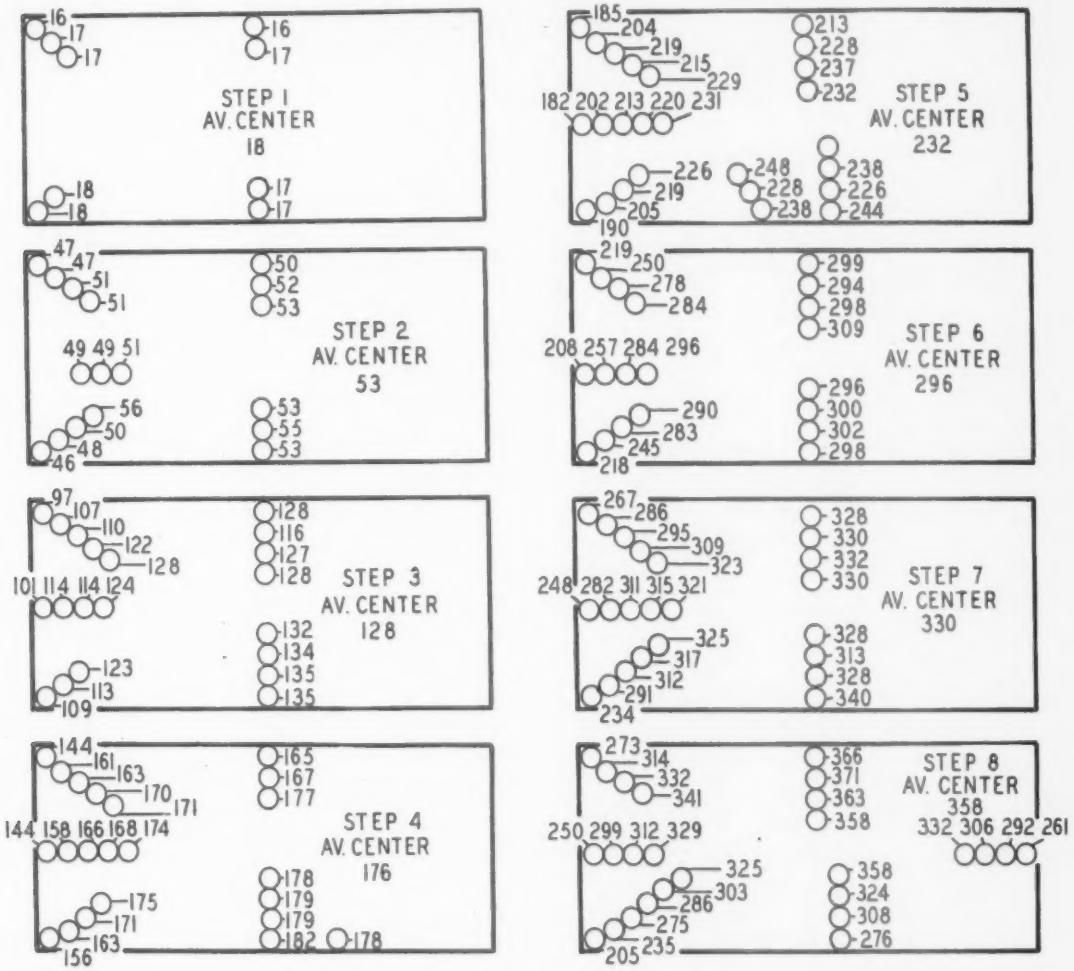


Fig. 109, A and B. The magnitudes of the gradients may be estimated from the brightness values (using the Bausch and Lomb densitometer) inserted at the approximate location of reading. Step 8, the brightest step, has in addition to the typical gradients present in the other steps, a special case of the diagonal from the corner surrounded on two sides by dark film. This gradient (205–358) is notably larger than those from the center of the step toward the center (250, 261, 276–358).

as the Al penetrometer. Therefore, in spite of photographic (and possibly densitometer) aberrations, we believe the peripheral enamel actually is more radiopaque than the inner portion of the tissue.

Since Step 5 has approximately the same magnitude of readings as the enamel, it is of interest to note that in Step 5 a gradient is found of 185 cm. to 232 cm. which represents a 20 per cent difference—roughly 3× the standard deviation. On the other hand, the gradient in the enamel is 177 cm. to 203 cm., or only 13 per cent.

In order to find values for the gradients (average center reading-peripheral reading) near the periphery of the Al penetrometer image, a series of films were measured carefully including the gradients denominated 1, 2, 3, and 4, as illustrated in Figure 109 A and B. In each step the gradient in from the center of the next thicker step (more transparent) is No. 1; in from the center of the next thinner step is No. 2; in from each edge of the dark film junction in from the corner of the next thinner (less transparent), in diagonally, is No. 3; in from the corner adjoining the next thicker step, diagnonally, is No. 4.

Table XCIII

	Film No.	No. Readings Center Step	Average of Center Readings	Range Including 70 Per cent of Readings (S.D.*)	Gradients (1)	(2)	(3)	(4)
	12	20	349	±3*	73, 99, 89	−17	76	144
	3	16	337	±8	84, 87, 132			152, 170
	21	18	298	±3	73, 85, 114			135, 123
Step 8	27	16	313	±3	45, 105, 78			110, 137
	28	19	325	±8	80, 65, 107			135, 109
	24	44	290	±15	145, 80			183, 205
	25	20	297	±8	54, 57, 84	−20		102, 123
	12	20	332	±4*	84	4, −8	98, 65	
	3	5	299		119			
	21	5	268		108			
Step 7	27	6	283		71			
	28	4	301		114			
	24	10	277		132, 66			
	25	20	260	±5	90, 44	−13, −11		
	12	20	297	±9*	89	−1, −2	79, 78	
	3	6	197		62			
	21	6	175		58			
Step 6	27	6	193		46			
	28	4	216		68			
	24	7	173		56, 78			
	25	20	180	±3	34, 62	−7, −13		
	12	20	234	7*	52	−10, 21	44, 49	
	3	4	116		29			
	21	7	103		32			
Step 5	27	5	115		19			
	28	4	134		41			
	24	8	102		22, 23			
	25	20	110	2	33, 14			
	12	20	178	4*	34	13, −4	22, 34	
	3	3	57		16			
	21	6	51		15			
Step 4	27	4	58		4			
	28	5	70		17			
	24	7	51		9, 16			
	25	20	55	1	2, 12			
Step 3	12	20	129	4*	28	−6, 6	32, 20	
Step 2	12	20	54	2*	5	1, 3	7, 8	
Step 1	12	20	18	0.5*		1, 2	2, 0	

The individual readings represent a body of data far too great to be reproduced here. Consequently in Table XCIII are given for 7 films, the film number, the number of readings in the center of each step, the average reading in the center, the range including 70 per cent of the readings in the center, and gradients Nos. 1, 2, 3, and 4. All of the above data are given for Steps 8 and 4, inclusive; the gradients in the denser steps, 3 to 1, are too small to be subject to calculations. The gradients in

Step 8 (Table XCIII) are of the largest magnitude and consequently presented in greatest detail. The average gradients are not given due to the marked variation in gradient magnitudes. However, it is clear (1) that the gradients exist, and (2) that the magnitude of the gradients decreases with decrease in brightness of the center of the step.

We studied intensively one of five identical exposures which had been made on "dupli-tized x-ray film" at 30 kv., 30 ma., 30 inches, 6 seconds, no tube stand filter, cardboard cassette.* Film 10293, chosen for study, has an average density in the film exposed to unfiltered radiation of 2.04 density units. The density under the various steps of the penetrometers range from 1.30 to 0.24. D.Rs. in the enamel average 0.40, in the dentine average 0.60. The I.Vs. for the enamel are 1.20 mm. Al, for the dentine 0.78 mm. Al; values in all respects typical. Using the Bausch and Lomb densitometer, we made preliminary measurements in which a deflection of 4.5 cm. was found in the film not under the penetrometer and a maximum deflection of 34 cm. in Step 8 (brightest). We discovered that the instrument is capable of much greater sensitivity than is evidenced by the magnitude of the deflections just given, consequently the size of the slit was enlarged and the magnification considerably increased. The deflections now found were approximately 2 cm. in the film not under the penetrometer and 300 cm. in Step 8, using a wall scale with a length of 12 feet, and a sensitive galvanometer approximately 15 feet from the wall scale. However, from each of these procedures the I.Vs. for the enamel and the dentine did not differ significantly from the values we had obtained using the Capstaff densitometer.

By using the greatly magnified image of the tooth and the greatly increased sensitivity of the instrument, measurements were made in the enamel of Tooth

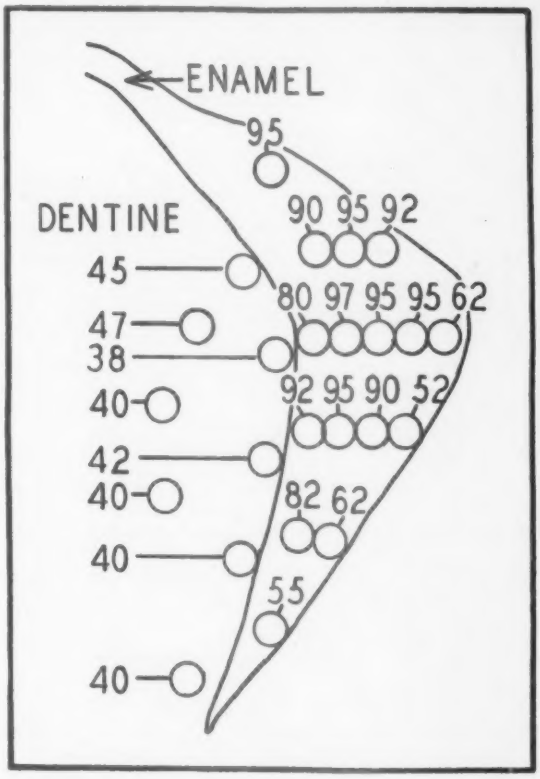


Fig. 107. Readings of brightness using a modified set-up with a Bausch and Lomb densitometer. The area of the circles illustrates the film areas measured. Note lower readings (less transparency) in the peripheral part of the enamel.

No. 1 as shown in Figure 107. The size of the circles indicates the approximate area measured. It is interesting to observe that in the five separate readings made from the periphery of the enamel to the dentine-enamel junction that instead of a high reading (brighter) in the periphery there is found a lower reading with a sort of gradient of increasing brightness toward the center of the enamel. A more careful study of the same film gave evidence that the gradient found in the enamel was also present in the various steps of the penetrometer. On Step 8, for example, the average deflection in that center of the step was 155 cm. with a standard deviation of 4.7 cm., or about 6 per cent; nevertheless, we noted that the readings which differed from the average occurred with annoying frequency and in a fairly regular fashion.

* Some of the films given in Table XCIII were paper wrapped, some in cardboard cassettes.

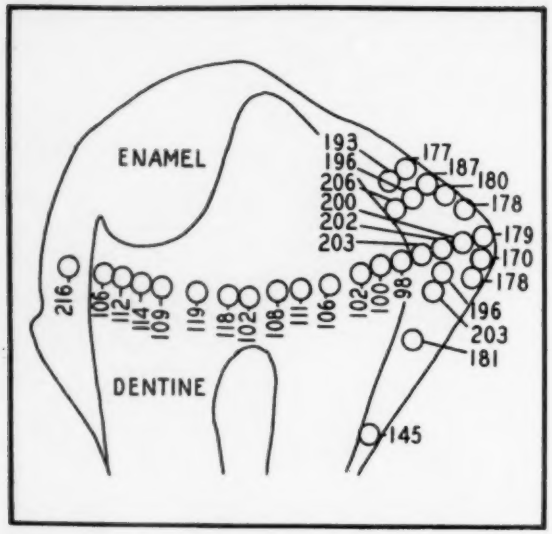


Fig. 108. Using a set-up of maximum sensitivity, readings made in the periphery of the enamel average 179 cm. while those in the central portion are about 200 cm. The peripheral dark line in the dentine (near the dentine-enamel junction) averages about 8 cm. less deflection than the average readings in the body of the dentine.

Thus it appeared that the densities in the outer portion of each step, i.e., close to the junction of the penetrometer with the dark film were uniformly greater than the densities in the center of each step. Since our galvanometer deflection increased with decreasing density it is therefore a direct function of the transparency and the readings which we obtained were smaller as we went from the center of each step toward the boundary between the step and the highly dense film.

In the enamel image (Fig. 107) the readings increase from 62 cm. to 97 cm. deflections from the edge towards the center of the enamel. This increase is directly comparable in magnitude to the increase found in Step 5 (72 to 90) whose transparency is about the same as that of enamel. If the readings are accepted as they stand, we must believe that there is a gradient of decreasing radiopacity in the enamel from the dentine-enamel junction toward the periphery. However, the previous observations with the Capstaff-Purdy densitometer would have led us to expect that a gradient of opposite sense, i.e., of increasing radiopacity should have been present. We were immediately forced to assume either that the gradient was an instrument error, or that if it is a real gradient it is a phenomenon not previously described probably because of the minuteness of the areas involved.

By further adjustment of the instrument we produced a range of 9 cm. for zero reading and 600 cm. for full deflections as measured on the wall scale. Using this more sensitive set-up, a series of measurements checked repeatedly have for the enamel and dentine deflections as illustrated in Figure 108.

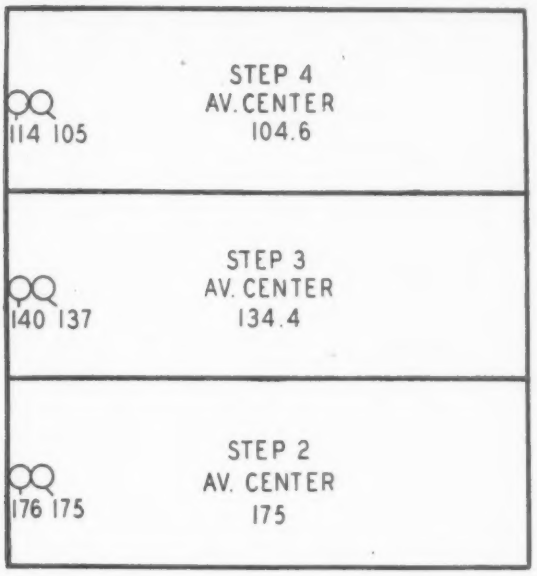
In the enamel, a concordant series of readings of about 179 cm. were made along the narrow edge of peripheral enamel (see Fig. 108) while the enamel nearest the dentine-enamel junction read uniformly about 202 cm.

In the areas in the dentine closest to the enamel, a dark line has been noted (see paper of Van Huysen et al.*) which is measurable by this densitometer and whose magnitude of transparency is 106 cm. compared to 114 cm. on the left side and 98 cm. compared to 106 cm. on the right side of the dentine (see Fig. 108). Readings in the body of the dentine ranged from 102 to 119 cm.

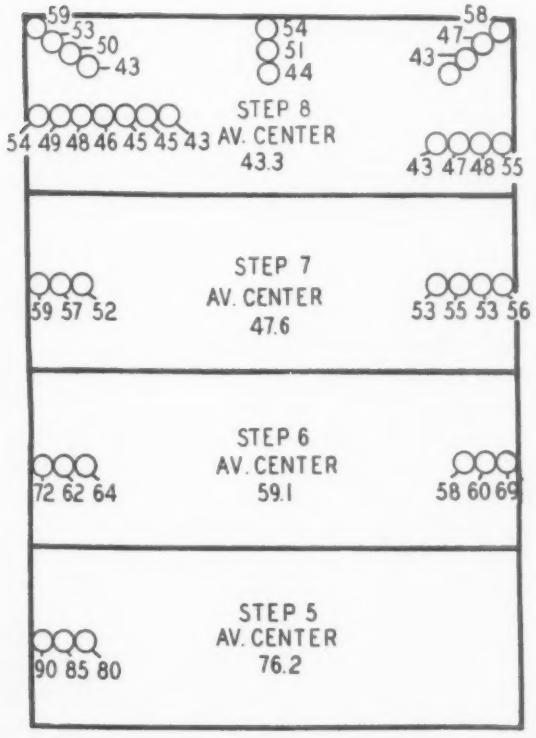
In Table xciii are given the averages for the readings in the center, and the standard deviation around each average. In general, the readings are reproducible to about 4–5 per cent. Thus in Step 5, the standard deviation is 7, the average reading 250 cm., and the per cent equals $7/232 \times 100$ equals 6 per cent.

After the establishment of the fact of a difference between the reading near the periphery of the step and near the center, one of the films (Film No. 25) was measured carefully with a Capstaff-Purdy densitometer. Somewhat to our surprise, we found a gradient in the densities exactly in accord with those present above,

* Van Huysen, Hodge, Warren and Bishop. *Dent. Cosmos.*, 1933, *75*, 729.



A



B

Fig. 110, A and B. The densities read from the Capstaff-Purdy densitometer are inserted at the approximate location read and confirm the presence of density gradients in the penetrometer. Note that the densities stand in inverse relation to the brightness readings given Figure 109, A and B.

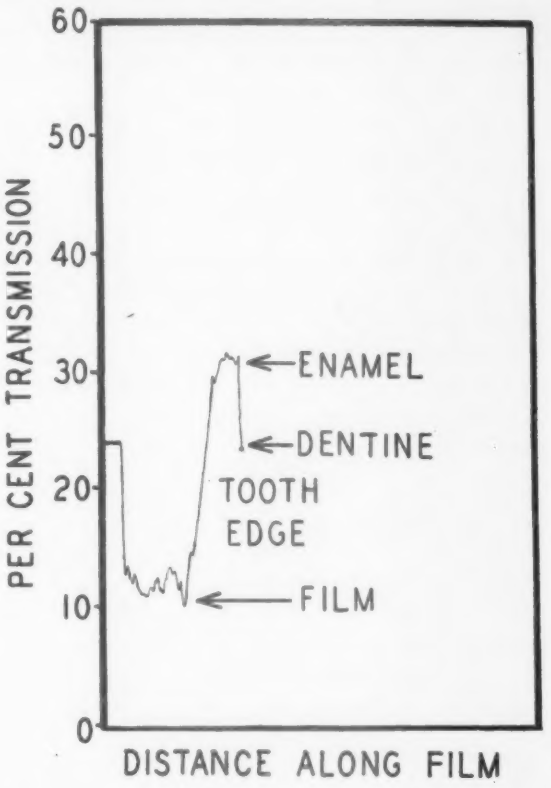


Fig. 111. There is some evidence of an increased density at the periphery of the enamel. Compare with Figure 102 which seems to indicate that the center portion of the low density step has a greater per cent transmission than the edge portions.

but of course, different numerically. These gradients are illustrated in Figure 110, A and B. Therefore, we may conclude that, if the gradient is an instrument error, it is also an instrument error in the Capstaff-Purdy densitometer.

Furthermore, a film was measured by the recording microdensitometer of Dr. L. A. Jones. The tracings reproduced in part in Figures 101 and 111 indicate that with this instrument although very sharp edges are obtained, i.e., very sharp resolution, nevertheless, the values in the low density step and in the enamel give evidence of decrease in density with distance from the periphery toward the center.

The data from the measurements in Table xciii were treated in a number of ways as follows: The brightness of the center was plotted against the thicknesses

of the steps, against the logarithm of the thicknesses. From these curves, no interpretations were possible.

Next, when the data for each of the gradients in from the dark film in Steps 4, 5, 6, 6, and 8 are plotted as ordinates against a roughly estimated distance in, i.e., approximately the slit width further into each step for each succeeding measurement, several relations become apparent. First, the amount of difference is greater in those steps whose transparency is greater. Second, the gradient between adjacent steps is not significantly different from the brightness of the center of the steps; the resulting curves showed an increasing slope with increasing brightness of the center of the steps but gave no new evidence; (*b*) plotting the thicknesses of step against the gradients and against the logarithm of the gradients; the resulting curves were not helpful.

The immediate application of the magnitude of the gradient to the stated "apparent" decrease in the absorption of the peripheral enamel enables us to make a calculation which indicates that instead of the "apparent" decrease there is really an increased radiopacity of peripheral enamel. Thus, for a thickness of Al absorbing approximately equally to enamel, we find that a difference between the reading near the edge and the average center reading will be about 50 if the material is uniform. In the enamel, the measured difference is found to be about 35 or 15 less than would be expected in a uniform material. The inference is that the outside edge of enamel is a little better absorber than the center, which corresponds with the original estimations made with the Capstaff-Purdy densitometer.

In attempting to get at the cause of the gradients, a number of possibilities were considered and the average data were studied in a number of ways. For instance, if the gradients were a result of roentgen-ray scattering from the film next to that protected by the penetrometer, there

Table XCIV

PERCENTAGE GRADIENT OF AVERAGE READING IN CENTER: GRADIENT NO. 1

Film No.	Step 8	7	6	5	4	3	2
12	21, 28, 26	26	30	22	19	22	9
3	25, 26, 39	40	32	25	28		
21	24, 29, 38	40	33	31	30		
27	14, 34, 25	25	24	17	7		
28	25, 20, 33	38	32	31	24		
24	50, 28	48, 24	32, 45	22, 32	18, 32		
25	18, 19, 28	35, 17	19, 35	30, 13	4, 22		
Average	28	33	31	25	20		

the readings in the center of the steps, since their magnitudes place them almost exclusively in the range included by the standard deviation (see Table XCIII).

The measurements of gradients in Step 8 are also made in the corner which extends into the dark film. From the geometry of this diagonal, any difference measured along it should be greater by the $\sqrt{2}$ than differences measured straight in from the center of the edge. To test this relation, the average gradient in from the edge is computed for Step 8 and compared to the average gradient in the corner in Table XCIV. It is evident that the relation is only fairly borne out since Av. Grad. from edge $\times\sqrt{2}$ should = Av. Grad. from corner but substituting 86×1.414 should = 148 or 122 = 148.

Further study of the data included the following: (*a*) plotting the gradients against

should be about an equal amount of scattered radiation added to the radiation transmitted by the various steps. Adding such a nearly constant amount to the varying amounts of radiation transmitted should give gradients whose magnitude would be a much larger proportion of the total blackening in the brighter steps than in the darker if all the densities lay in the straight line portion of the characteristic curve. To test this hypothesis, the gradients were compared to the brightness of the center of each step on a percentage basis. From Table XCIV it is seen that the gradients represent the following percentages of the center brightness in Steps 8 and 4, respectively: 28, 33, 31, 25, and 20 per cent. The constancy of the percentages is evidence that the hypothesis is not true, and that the gradient is not due to the scattering of roentgen radiation by the film close to the penetrometer.

However, the constancy of percentages is evidence of the absence of scattered roentgen radiation only in the event that the densities of the various steps of the penetrometer lie on the straight line portion of the density-logarithm exposure curve (paper VII). In a private communication, R. B. Wilsey pointed out that the constancy of percentage transmission differences also means a constancy of density differences between the peripheral and center portions of the steps. Furthermore, in the event that the densities include part of the toe of the characteristic curve constant density differences would require varying logarithm exposure differences, so that the effect of scattered radiation in the film emulsion next to the penetrometer cannot be thus ruled out.

The density gradients may be qualitatively attributed to three sources: (1) the scattered radiation, (2) the densitometer, and (3) the development process. These sources are arranged in order of probable influence. The magnitude of the density differences is much smaller when measured using a densitometer (built in this laboratory) which employs an optical slit system similar to the recording microdensitometer of L. A. Jones. Scattered light in the densitometer may account for as much as 50 per cent of the magnitude of the gradients given in Table XCIII. On the other hand, every instrument used has given evidence of a density gradient. The relative influences of the development process and the scattered radiation in the exposure are difficult to evaluate. In an effort to check these factors, a series of films were made in which a lead mask (one-eighth inch) was placed over the penetrometers with slits so arranged as to expose only the inner portions of the penetrometers. In these films, almost no radiation struck the films near the penetrometers and scattered radiation in the emulsion was reduced to a minimum. Somewhat surprisingly, gradients were found in the various steps of the penetrometer images, but the direction of the gradients was reversed. Instead of denser areas in the peripheral portions, less dense areas were observed. It is still impossible to rule out either development or scattered radiation in the emulsion, since the areas around the penetrometers were of very low density (0.5) but radiation striking the center of the penetrometers provided more chance of scattering (in the emulsion) than in the periphery. However, since a great deal of radiation strikes the emulsion near the penetrometers in films exposed in the usual manner, which give denser areas near the very black (densities of 3.5 or greater) film, and since the opportunity for scattered radiation in the emulsion is limited to the penetrometer in the lead-masked films which give lighter areas near the clear film, the density gradients may be tentatively attributed principally to the effect of scattered radiation in the emulsion.

SUMMARY

The discovery of a white line at the periphery of the enamel image led to an attempt to measure densities in this zone. The white line was shown to be the "Mackie line," a developmental phenome-

non, by Hollander and Saper. We found another density anomaly: the measured densities decrease from the periphery of the enamel toward the more or less uniform readings in the center part. This "density gradient" is shown to exist in the peripheral portions of the Al penetrometer but is of greater magnitude than the gradient in the enamel. The inference is drawn that enamel is not of uniform radiopacity but is more radiopaque in the peripheral portion. The effect of scattered radiation in the emulsion cannot be ruled out and may explain the presence of the "density gradients."

CONCLUSIONS

1. Using the technique described by Warren et al., sufficient image sharpness is achieved to permit quantitative density measurements.

2. Variations in emulsion thickness are probably not casual agents of the known density gradients across the penetrometer.

3. A definite filtration effect of the photographic emulsion is demonstrated. Increasing the filtration effect by increasing the number of films penetrated by the roentgen-ray beam, gives lower I.Vs. for the enamel and no change for the dentine, a predicted result.

4. There are two density phenomena in the periphery of the enamel: (1) a white line at the periphery (the "Mackie line"), and (2) a "density gradient" in which the density decreases from the periphery towards the uniform center portion. Similar "density gradients" are found in the periphery of the Al penetrometer, but in that part of the penetrometer which absorbs an amount of radiation identical with that absorbed by enamel, the "density gradient" in the aluminum is greater than that in the enamel. If the aluminum is uniform, then the enamel must be more radiopaque in its peripheral portion.

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EDITORIALS

MAMMOGRAPHY

SINCE Warren's first report on the roentgenological study of the breast, numerous observers have called attention to the importance of the roentgen ray in the study of breast tumors, notably Lockwood, and Reimann and Seabold. The procedure has offered such diagnostic possibilities that it has become almost a routine in nearly all roentgen-ray departments.

The importance of the roentgen ray in the diagnosis of breast tumors is not generally appreciated among the medical profession. With Warren's diagnostic accuracy of 85 to 95 per cent in the differential diagnosis of breast tumors, it would hardly seem necessary that other roentgenographic methods would be indicated, though the work of Hicken[1] in his examination by the use of contrast media offers an additional method in the roentgen study of breast tumors. This procedure utilizes contrast fluids which are injected directly into the milk ducts, thus giving an accurate roentgenographic pattern of the ductal and secretory system of the mammary gland. Various contrast media were employed in the study, but it was found that thorotrast was the most suitable; in addition to being the least irritating it also possesses the distinct advantage of having a sufficient fluidity to enter the smallest lacteals and still be dense enough to cast a satisfactory shadow.

The technique of mammography, as Hicken designates the study, is very simple. The breast is thoroughly cleansed, as for any surgical procedure, and a gentle massage of the nipple done which expresses small droplets of secretion or inspissated plugs of material from the lactiferous ducts. By this procedure the openings of the ducts are accurately located and can be readily cannulized by a blunt needle. The contrast fluid is then injected into the duct until a sense of discomfort is experienced by the patient. This is repeated until all available ducts, usually eight or ten in number, have been injected, and then stereoscopic roentgenograms are taken.

Hicken has found, after his experience in a number of cases, that this method of examination offers an excellent means of studying both the physiological and pathological changes of the breast. By this method one is definitely able to differentiate localized from infiltrating growths, solid from cystic tumors, and simple retention cysts from cystic degeneration of the breast, and in addition it is possible to determine the number and size of papillomas present. As might be expected from the nature of the growth infiltration, carcinomatous tumors of the breast are not easily visualized by these contrast studies, and Hicken emphasizes again the possibility of massage of malignant tissues expressing some of the neoplastic material into the lymphatic or vascular circulation, and he suggests that if the tumor is frankly carcinomatous there is no need for contrast injection. Certainly the work of Warren, Lockwood and others has emphasized the diagnostic features of neoplastic processes in the breast sufficiently to make it unnecessary to do an injection with contrast medium in order to give a correct diagnosis, though if a tumor be small and the injection carefully made, the contrast method of examination is of great importance in a differential diagnosis in deep-seated neoplasms.

Hicken concludes from his experience

[1] Hicken, N. F. Mammography; the roentgenographic diagnosis of breast tumors by means of contrast media. *Surg., Gynec. & Obst.*, March, 1937, *64*, 593–603.

and study that mammography is an efficient method of visualizing the breast by introducing contrast media into the small estuaries of the nipple or directly into the tumor mass. The contrast substances clearly outline the milk ducts and the tumors, thus facilitating accurate diagnosis, and since the technique is a relatively simple one, though at times a tedious procedure, it offers sufficient additional information to warrant its use in many cases of obscure tumors of the breast.

JOSEPH M. STEINER
1880–1937

IN THE death of Dr. Joseph M. Steiner on January 25, 1937, medicine has received an irreparable loss.

He was born in Greenville, Alabama, on June 23, 1880, the son of Ida Alice Hawthorne and Joseph Manning Steiner. After having been graduated from the Greenville High School, he attended the Polytechnic Institute at Auburn, Alabama, and having completed his course of study there, he went to Tulane University, New Orleans, where he took his medical degree in 1904. He was a member of the Nu Sigma Nu Fraternity.

Following his graduation Dr. Steiner practiced medicine in Greenville for a year

and then moved to Denver, Colorado, where in 1906 he became associated with the Agnes Memorial Sanatorium as bacteriologist, and it was at this time that he began his work in roentgenology which he was destined to follow so successfully.

In 1916 he moved to New York City where he was associated with Dr. Lewis Gregory Cole both in private practice and at the French Hospital. When the United States entered the World War he joined the Roosevelt Hospital Unit and early in July, 1917, went overseas and was located at the General Headquarters at Chaumont, France. He was a Major in the Medical Reserve Corps of the Army.

After the war he returned to New York City and continued his association with Dr. Cole, becoming especially interested in roentgenological therapeutics at the French Hospital where he took charge of one of the first 200,000 volt machines in the country. Upon his return from the war he also became roentgenologist at Roosevelt Hospital, reorganizing the department. When the Doctor's Hospital was completed in 1922 he was appointed roentgenologist and continued there in active practice until the first of December, 1936. At that time he retired because of ill health and, accompanied by his family, went back to his home in Greenville.

Dr. Steiner was married on December 26, 1911, to Miss Lillian Shears of Omaha who survives him as do his daughter, Alice Hawthorne Steiner, and two sons, Joseph Manning Steiner, Jr. and Lewis Cole Steiner.

As a result of his ten years of service at the Agnes Memorial Hospital he acquired a particularly active interest in roentgenology of the chest. He was also coeditor with Dr. Cole of the chapter on Roentgenology in Keen's "Surgery."

An ardent golf enthusiast, Dr. Steiner was a member of the Scarsdale Golf Club for many years. He was particularly adept at bridge and, as many of us can personally testify, he was more welcome as a partner than as an opponent.

He was a member of the American Roentgen Ray Society, the New York Academy of Medicine and the Radiological Society of North America. At one time he was Chairman of the Section on Roentgenology of the New York State Medical Society. In 1928 Dr. Steiner was sent as a delegate from the American Roentgen Ray Society to the Second International Congress of Radiology in Stockholm.

His death, which was the result of a fall in which he sustained a fracture of the skull, has left an unfortunate vacancy in the ranks of roentgenology and in the hearts of his friends who remember him for his charming and amiable personality.

Lewis Gregory Cole

THOMAS ORVILLE MENEES
1890–1937

TAKEN from life in the prime of productivity, the last few years of which he spent in intensive study of contrast media, Dr. Thomas O. Menees died suddenly while reading, on the evening of February 14, 1937.

Dr. Menees was born in Nashville, Tennessee, on March 5, 1890. He came from a prominent pioneer family. His great-grandfather opened the first private school in Tennessee. His grandfather was Professor of Anatomy and Dean of the Vanderbilt University School of Medicine. His father Orville H. Menees, was Professor of Anatomy and Histology at Vanderbilt University School of Medicine and

Professor of Pathology and Oral Surgery in the School of Dentistry at the time of his death. His mother, Malinda Atchison Headley Menees, died when he was two years old. His father died when Thomas was four years old.

Dr. Menees graduated from Hume Fogg High School in 1907 and entered Vanderbilt University the following fall for one year of Academic Training, associating himself with the Alpha Iota Chapter of Phi Kappa Sigma. He transferred to Medicine in 1908 and graduated in 1912. During that time he was affiliated with the Phi Chi Fraternity. After a trip abroad he was associated with the Department of Physiology; later specializing in Roentgenology. He opened an office in Nashville, Tennessee, in 1914 but retired from practice after a short time for further travel.

Dr. Menees enlisted in the United States Army in September, 1917, serving as First Lieutenant, Medical Corps. He was sent to Fort Benjamin Harrison and transferred to the Army X-ray School at Cornell University in November of that year, where he remained until he went overseas May 19, 1918, with Base Hospital Unit No. 13. He returned March 23, 1919, and was discharged at Carlisle, Pennsylvania, July 14, 1919. He was awarded the Victory Medal, November 26, 1920.

Dr. Menees came to Blodgett Memorial Hospital, Grand Rapids, Michigan, as Roentgenologist in July, 1919, which position he held at the time of his death. He spent the fall of 1930 in post-graduate study in Vienna, taking particular interest in radiation therapy and study of the bones of the skull.

He was a member of the following societies: Kent County Medical Society, Michigan State Medical Society, American Medical Association, American College of Radiology, Radiological Society of North America and American Roentgen Ray Society; he was a diplomate of the American Board of Radiology.

He was married in New York City on November 14, 1917, to Mary Elizabeth Jones, of Lexington, Kentucky. He is survived by the widow and two sons, Thomas, Jr., and James, aged eighteen and eleven, respectively.

Dr. Menees had done much original and outstanding work, notably in cholecystography and amniography, and the day before his death he had practically completed his research on an improved medium for oral cholecystography, a report of which was to have been presented at the International Congress of Radiology in Chicago, in September.

Dr. Menees truly followed in the footsteps of his ancestors. He was a man of sterling qualities, a profound scholar, a keen thinker and a most excellent teacher with a deep understanding of the fundamental principles of the roentgen ray and its application. He had a broad knowledge of medical literature, an accurate memory and an unusually keen sense of observation, which made him a great radiologist, whose opinions and consultations were most highly valued and he always gave freely of his knowledge and experience. He was possessed of that unusual type of mind which showed brilliance best when engaged in original investigation. His untimely death has taken from roentgenology one who would undoubtedly have been one of the leaders in his profession.

SOCIETY PROCEEDINGS, CORRESPONDENCE AND NEWS ITEMS

Items for this section solicited promptly after the events to which they refer.

MEETINGS OF ROENTGEN SOCIETIES*

United States of America

American Roentgen Ray Society
Secretary, Dr. F. P. Pendergrass, University Hospital, Philadelphia, Pa. Annual Meeting: Chicago, Ill., Sept. 13–17, 1937.

American College of Radiology
Secretary, Dr. B. H. Orndoff, 2561 N. Clark Street, Chicago, Ill. Annual meeting: Atlantic City, N. J., June, 1937.

Section on Radiology, American Medical Association
Secretary, Dr. J. T. Murphy, 421 Michigan St., Toledo, Ohio. Annual meeting: Atlantic City, N. J., June 9–11, 1937.

Radiological Society of North America
Secretary, Dr. D. S. Childs, 607 Medical Arts Bldg., Syracuse, N.Y. Annual meeting: Chicago, Ill., Sept. 13–17, 1937.

Radiological Section, Baltimore City Medical Society
Secretary, Dr. Howard H. Ashbury, Baltimore. Meets third Tuesday each month, September to May.

Radiological Section, Connecticut State Medical Society
Secretary, Dr. Max Climan, 242 Trumbull St., Hartford, Conn. Meets annually in May. Special meetings may be called by the Chairman.

Radiological Section, Los Angeles County Medical Society
Secretary, E. N. Liljedahl, Los Angeles, Calif. Meets on the second Wednesday of each month at the County Society Building.

Radiological Section, Southern Medical Association
Secretary, Dr. Roy G. Giles, Temple, Texas.

Brooklyn Roentgen Ray Society
Secretary, Dr. E. Mendelson, 120 E. 19th St., Brooklyn, N. Y. Meets monthly on first Tuesday, October to April.

Buffalo Radiological Society
Secretary-Treasurer, Dr. Joseph S. Gian-Franceschi, 610 Niagara St., Buffalo, N. Y. Meets second Monday of each month except during summer months, place of meeting selected by the host.

Chicago Roentgen Society
Secretary, Dr. R. G. Willy, 1138 N. Leavitt. Meets second Thursday of each month October to May inclusive at the Palmer House.

Cincinnati Radiological Society
Secretary, Dr. H. G. Reineke, General Hospital Cincinnati, Ohio. Meets third Monday of each month, October to May, inclusive.

Cleveland Radiological Society
Secretary, Dr. North W. Shetter, 14600 Detroit Ave. Meetings are held at 6:30 P.M. at the Cleveland Chamber of Commerce Club rooms on the fourth Monday of each month from October to April, inclusive.

Denver Radiological Club
Secretary, Dr. N. B. Newcomer, 306 Republic Bldg., Denver, Colo.
Meets on the third Tuesday of each month.

Detroit Roentgen Ray and Radium Society
Secretary, Dr. E. R. Witwer, Harper Hospital. Meets monthly on first Thursday from October to May, at Wayne Country Medical Society Building.

Florida State Radiological Society
Secretary, Dr. Harold O. Brown, Tampa, Florida. Meetings held twice a year, May and November.

Illinois Radiological Society
Secretary, Dr. Cesare Gianturco, 602 W. University Ave., Urbana, Ill. Regular meetings held quarterly.

Indiana Roentgen Society
Secretary, Dr. C. C. Taylor, Indianapolis, Ind. Meeting held the second Sunday in May annually.

Long Island Radiological Society
Secretary, Dr. S. G. Schenck, 115 Eastern Parkway, Brooklyn, N.Y. Meets at Kings County Med. Soc. Bldg. on third Thursday of each month from October to May, at 8:30 P.M.

Michigan Association of Roentgenologists
Secretary, Dr. C. S. Davenport, St. Lawrence Hospital, Lansing, Mich. Three meetings a year, Fall, Winter, and Spring.

Milwaukee Roentgen Ray Society
Secretary, Dr. S. A. Morton, Columbia Hospital, Milwaukee, Wis. Meets monthly. Place of meeting named by the president.

Minnesota Radiological Society
Secretary, Dr. L. G. Rigler, University Hospital, Minneapolis, Minn.

Nebraska State Radiological Society
Secretary, Dr. D. A. Dowell, Medical Arts Bldg., Omaha, Nebr. Meets third Wednesday evening of each month.

New England Roentgen Ray Society
Secretary, Dr. E. C. Vogt, 300 Longwood Ave., Boston, Mass. Meets monthly on third Friday, Boston Medical Library.

Radiological Society of New Jersey
Secretary, Dr. P. S. Avery, New Brunswick, N. J. Meets annually at time and place of State Medical Society. Mid-year meetings at place designated by the president.

New York Roentgen Society
Secretary, Dr. R. W. Lewis, 140 E. 54th St., New York. Meets monthly on third Monday, New York Academy of Medicine, at 8:00 P.M.

North Carolina Roentgen Ray Society
Secretary, Dr. Major Fleming, Rocky Mount, N. C. Annual meeting at time and place of State Medical Society. Mid-year scientific meeting at place designated.

Central New York Roentgen Ray Society
Secretary, Dr. C. F. Potter, 820 S. Crouse Ave., Syracuse, N. Y. Three meetings a year—January, May, and November.

Pacific Roentgen Club
Secretary, Dr. L. H. Garland, 450 Sutter St., San Francisco, Calif. Meets annually during meeting of California Medical Association.

Pennsylvania Radiological Society
Secretary, Dr. L. E. Wurster, Williamsport, Pa. Two day annual meeting will be held Friday and Saturday, May 21 and 22, 1937, Hotel Lawrence, Erie, Pa.

Philadelphia Roentgen Ray Society
Secretary, Dr. B. R. Young, Temple University Hospital. Meeting first Thursday of each month from October to May inclusive, at 8:15 P.M., in Thompson Hall, College of Physicians, 19 S. 22d St.

Rochester Roentgen Ray Society, Rochester, N. Y.
Secretary, Dr. Camp C. Thomas, 476 Lake Ave. Meets on second Thursday from October to May, inclusive, 8 P.M., Rochester Academy of Medicine Building.

St. Louis Roentgen Ray Society
Secretary, Dr. P. C. Schnoebelen, Missouri Bldg., St. Louis, Mo. Meets first week of each month. Time and place of meetings designated by president.

South Carolina X-Ray Society
Secretary, Dr. R. B. Taft, 105 Rutledge Ave., Charleston. Meets at time and place of South Carolina State Medical Association.

Tennessee Radiological Society
Secretary, Dr. F. B. Bogart, 311 Medical Arts Bldg.

* Secretaries of Societies not here listed are requested to send the necessary information to the Editor.

Chattanooga, Tenn. Meets annually at the time and place of the Tennessee State Medical Association.

Texas Radiological Society
Secretary, Dr. M. H. Glover, 414 Hamilton Bldg., Wichita Falls, Texas. Meets twice a year. Mid-year meeting on opening day of Texas State Medical Association, Fort Worth, May 10, 1937.

University of Michigan Department of Roentgenology Staff Meeting
Secretary, Dr. C. B. Peirce, University Hospital, Ann Arbor, Mich. Meets each Monday evening from September to June, at 7 P.M. at University Hospital.

University of Wisconsin Radiological Conference
Secretary, Dr. F. A. Pohle, 1300 University Ave., Madison, Wis. Meets every Thursday from 4:00-5:00 P.M., Room 301, Service Memorial Institute.

Virginia Roentgen Ray Club
Secretary, Dr. V. W. Archer, University Hospital, University, Va.
Meets annually in October.

Cuba

Sociedad Cubana de Radiologia y Fisioterapia
Secretary, Dr. Francisco Padron, Enrique, Villuendas 64, Havana, Cuba. Meets monthly in Havana.

British Empire

British Institute of Radiology Incorporated with the Röntgen Society
Meets on the third Thursday of each month, from November to June inclusive, at 8:15 P.M., at 32 Welbeck St., London, W. 1, or as advertised.

Section of Radiology of the Royal Society of Medicine (Confined to Medical Members)
Meets on the third Friday of each month during the winter at 8:15 P.M. at the Royal Society of Medicine, 1, Wimpole St., London, W. 1.

Section of Radiology and Medical Electricity, Australasian Medical Congress
Secretary, Dr. H. M. Cutler, 139 Macquarie St., Sydney, New South Wales.

Radiological Section of the Victorian Branch of the British Medical Association
Secretary, Dr. Keith Hallam, St. George's Hospital, K.E.W., Melbourne, E. 4, Victoria, Australia. Meets monthly from March to Nov. incl. for scientific discussions.

Section on Radiology, Canadian Medical Association
Secretary, Dr. A. C. Singleton, Medical Arts Bldg., Toronto 5, Ontario.

Radiological Section, New Zealand British Medical Association
Secretary, Dr. P. C. Fenwick, The Hospital, Christchurch. Meets annually.

Continental Europe

Belgian Society of Roentgenology
Secretary, Dr. J. Boine, Avenue des Alliés, 134, Louvain (Belgium).
Meets monthly on second Sunday at d'Egmonds Palace, Brussels, except in the summertime.

Sociedad Española de Radiologia y Electrologia
Secretary, Dr. J. Martin-Crespo, Fuencarral, 7, Madrid, Spain. Meets monthly in Madrid.

Société de Radiologie Médicale de France
Meets monthly on second Tuesday, except during months of August and September, 12 Rue de Seine, Paris.

Société Suisse de Radiologie (Schweizerische Röntgen-Gesellschaft)
Secretary for French language, Dr. A. Grosjean, La Chaux de Fonds.
Secretary for German language, Dr. Scheurer, Molzgasse, Biel.
Meets annually in different cities.

Société Francaise d'Electrothérapie et de Radiologie Médicale
Meets monthly on fourth Tuesday, except during months of August and September, 12 Rue de Seine, Paris.

Association of German Roentgenologists and Radiologists in Czecho-Slovakia
Secretary, Dr. Walter Altschul, German University, Prague, II.52.

Deutsche Röntgen-Gesellschaft (Gesellschaft für Röntgenkunde und Strahlenforschung)
Meets annually in April, alternating one year in Berlin, one year in some other German city. Meets in addition every two years with the Gesellschaft deutscher Naturforscher und Aerzte.
Permanent secretary, Professor Dr. Haenisch, Klopstockstrasse 10, Hamburg, Germany.

Süd- und Westdeutsche Röntgengesellschaft
Meets annually in different cities.

Nord- und Ostdeutsche Röntgengesellschaft
Meets annually in different cities.

Dutch Society of Electrology and Roentgenology
Holds two meetings a year in Amsterdam, one in the Spring, and one in the Fall.

Societa Italiana Radiologia Medica
Secretary, Professor M. Ponzio, University of Turin, Turin.

Societatea Romana de Radiologie si Electrologie
Secretary, Dr. Oscar Meller, Str. Banul Mărăcine, 30, S. I., Bucuresti, Roumania.
Meets second Monday in every month with the exception of July and August.

All-Russian Roentgen Ray Association, Leningrad, USSR in the State Institute of Roentgenology and Radiology, 6 Roentgen St.
Secretaries, Drs. S. A. Reinberg and S. G. Simonson, Meets annually.

Leningrad Roentgen Ray Society
Secretaries, Drs. S. G. Simonson and G. A. Gusterin.
Meets monthly, first Monday at 8 o'clock State Institute of Roentgenology and Radiology, Leningrad.

Moscow Roentgen Ray Society
Secretaries, Drs. L. L. Holst, A. W. Ssamygin and S. T. Konobejevsky.
Meets monthly on the first Monday at 8 o'clock, the place of meeting being selected by the Society.

Polish Society of Radiology
Secretary, Dr. Jan. Kochanowski, 45 Gornoslazka St., Warsaw. Meets annually.

Warsaw Section, Polish Society of Radiology
Secretary, Dr. B. Krynski, 11 Zielna St.
Meets once a month except in the summertime.

Scandinavian Roentgen Societies
The Scandinavian roentgen societies have formed a joint association called the Northern Association for Medical Radiology, meeting every second year in the different countries belonging to the Association. Each of the following societies, with exception of the Denmark Society, meets every second month except in the summertime.

Society of Medical Radiology in Sweden
Meets in Stockholm.

Society of Medical Radiology in Norway
Meets in Oslo.

Society of Medical Radiology in Denmark
Secretary, Dr. G. Biering, Copenhagen.
Meets on the second Wednesday of each month from October to July in Copenhagen, at 8 o'clock in the State Institute of Roentgenology.

Society of Medical Radiology in Finland
Meets in Helsingfors.

Vienna Roentgen Society
Meets first Wednesday of each month, at 6.30 P.M. at Zentral-Röntgen Institut des allgemeinen Krankenhauses Alserstrasse 4.

Orient

Japan X-Ray Association
c/o Orthopedic Surgery, Tokyo Imperial University.
Meets annually in April.

Kinki Roentgen-Abend Society
Director, Dr. Prof. Taiga Saito, Ogawaoike Tyoto Japan. Meets bi-monthly on third Sunday.

REPORT OF RADIOLOGICAL INTER-SOCIETY COMMITTEE

The following is a report of the first meeting of the Radiological Inter-Society Committee held at the Palmer House, Chicago, Illinois, February 14, 15 and 16, 1937. All the members of the Committee, Dr. A. C. Christie, Chairman, Dr. E. H. Skinner and Dr. L. S. Goin, Secretary, were present.

Where there is no unity of action there will be a paucity of good results, whether the objective be the conquering of a nation or the diffusion of ideas. For some years the radiologists of America have felt the need for unified action in order that the ideals of radiology might be realized, and our specialty might take its rightful place among the subdivisions of the Practice of Medicine.

Activated only by the realization that some organization must take the first step, the Chancellors of the American College of Radiology, at their meeting in February, 1936, named a committee of three which it was hoped would be acceptable to all the radiological societies and might thus fairly represent all, or nearly all, American radiologists. At its annual meeting in September, 1936, the American Roentgen Ray Society appointed the same committee to be its representative, and in December, 1936, the Radiological Society of North America took a like action. This movement having been endorsed in 1934 by the American Radium Society, the body of American radiologists found itself for the first time represented as a unity in its various national affairs and interests.

In November, 1936, the Julius Rosenwald Fund announced the gift of $100,000 to the American Hospital Association to be used in the study and furtherance of group hospitalization plans. Since this is a subject in which radiologists are keenly interested the Inter-Society Committee at once prepared a letter for transmission to the proper committee and the officers of the American Hospital Association. The Committee expressed deep interest in the various group hospitalization plans and the liveliest desire to cooperate with the American Hospital Association in their formation and development. The letter follows:

In order to better co-ordinate the activities of the Radiological Societies of America, and to more clearly and authoritatively set forth the views of American radiologists, the National Societies named above have constituted a joint committee to represent them in such matters as may be considered pertinent to the purposes for which the Committee was formed.

This Committee, representing all of the National Societies of radiologists, and thus practically all radiologists of America, notes the gift by the Julius Rosenwald Fund to be used for the furtherance and betterment of voluntary Hospital Service plans. Like all physicians, radiologists are interested in such plans, and are anxious to co-operate fully in their organization and operation. It is undoubtedly true that the majority of American families are poorly prepared to meet the sudden demands of severe illness, and constructive steps toward enabling such demands to be met should be encouraged and supported by all physicians and by their clientele. Not only as physicians, but as citizens, we have the strongest desire to co-operate in the study and furtherance of hospitalization plans, and anticipate the day when the hospitalization of all those who may come within their scope shall be under a hospitalization service plan, and it is our strongest desire to engage in friendly discussion with your committee concerning the exclusion of medical services and especially radiological practice from group hospitalization plans and contracts.

Simply stated, the questions which concern us most deeply are these: Shall Radiology be included in Voluntary Hospital Insurance plans? If this question is answered in the affirmative, then shall it be included as (a) a hospital service, or (b) as a medical service so closely allied to hospital service as to be inseparable in practice, but to be paid for by indemnification? If it can be established that Hospital Insurance plans are not feasible without the inclusion of Radiology, then the answer to our first question *must* be in the affirmative and we must pass at once to the second question and bend all our efforts toward its satisfactory solution.

But can it be so established? It is essential that X-ray services be provided as part of hos-

pital service, and will it be possible to devise satisfactory and workable plans for its inclusion? To these questions we are constrained to answer: "*NO*". No one disputes the thesis that Radiology is a medical specialty, that it is a department of the practice of medicine, and that its practitioners are and must be physicians. This being true, then it is not difficult to see that if X-ray services are included in a hospital insurance plan, surgical, obstetrical, and urological service could be included with equal propriety. When such services *are included*, we will have taken irrevocable steps toward the complete socialization of both Medicine and Hospitalization, and Compulsory Health Insurance will be upon us.

To argue (as has been done) that only the so-called "technical services" will be included, is to state a thesis incapable of being successfully defended. No professional procedure can be divided into parts without the fatal wounding of that professional procedure. No one conversant with the problem can have any doubt but that such separation will result in two things: the ruin of a medical specialty, and increasingly poor practice within hospitals. Examples and arguments can be drawn at great length but are not necessary here. We will be glad to amplify any of these points to any degree if you deem it advisable.

May we call your attention to the fact, known to you, of course, that the oldest and most successful of the plans now in operation, namely, the Baylor (Dallas, Tex.) and Washington, D. C. plans, do not include and never have included X-ray services? The Memphis (Tenn.) plan has lately discontinued its X-ray benefits. The Alameda County (Cal.) plan furnishes X-ray and clinical pathology as a medical service, but does so by indemnifying its subscribers for the amounts expended by them. The Intercoast Society (California) has a like provision. It would seem, therefore, that it is possible to operate these plans without the inclusion of these medical services.

May we not ask you, then, to consider carefully, and to consult further with us, before making any recommendations which may not only destroy a medical specialty, but may lead to a lowering of hospital standards, to a lessening of the value of the service received by patients, and may even result in placing numerous hospitals in the unenviable position of violating the several Medical Practice Acts?

We will welcome inquiry or further discussion, and beg the privilege of bringing you the opinions, reactions, and joint experience of the Radiologists of this country.

Sincerely yours,

(Signed) Arthur C. Christie, M.D.
Edward H. Skinner, M.D.
Lowell S. Goin, M.D.

This letter was courteously received and a conference with representatives of the American Hospital Association was arranged in Chicago, at which conference the Committee was able to exchange views and to present the viewpoint and ideals of radiologists. It is needless to say that had the Committee been unable to present itself as representative of all of the American radiological societies and hence of all American radiologists, its efforts must have been much less effective.

Meeting with a larger group from the American Hospital Association an agreement as to the principles governing the relationship of hospitals and radiologist was reached. This agreement, which is a most happy solution to certain very vexing problems, states:

In view of the current discussions concerning the relationship of radiologists to hospitals and because of the desirability of protecting the public, of maintaining radiological services of high efficiency, and of safe-guarding the hospitals, the hospital radiologist and the interests of the non-hospital radiologist, the following basic principles are hereby approved by the Board of Trustees of the American Hospital Association.

1. The radiological service of the hospital shall be maintained primarily for the benefit of the sick.

2. Every hospital radiological department should be under the direction of a competent radiologist, preferably a diplomate of the American Board of Radiology.* If, because of size or isolation, such arrangement be not feasible, some member of the general medical staff trained in radiology should be in charge and a consultation service arranged with a nearby radiologist.

3. *The radiologist is entitled to recognition as a professional member of the medical staff and as head of a hospital department.*

* In Canada this would read "American Board of Radiology or an equivalent body."

4. *The preservation of the unity of the hospital and its component departments and activities is an essential administrative principle. This principle can be maintained without any infringement on professional rights or professional dignity.*

5. Inasmuch as no one basis of financial arrangement between a hospital and its radiologist would seem to be applicable or suitable in all instances, that basis should be followed which would best meet the local situation. This may be on the basis of salary, commission or privilege rental, but in no instance should either the hospital or the radiologist exploit the other or the patient.

6. When an arrangement is effected whereby the radiologist of the hospital pays a rental for space and service, cares for non-pay patients and in return retains all private fees collected, such contract should clearly cover the matter of depreciation of equipment, replacements and additions, should protect the radiologist against excessive non-pay work and should take into consideration the "goodwill" by virtue of which a large proportion of the paying clientele is attracted.

7. The American Hospital Association views with disapproval the proposal that the actual cost of films and associated overhead be separated from the professional charges of the radiologist or that the responsibility for this department be divorced from the hospital. While in many instances this would be a financial relief to the hospitals, it would probably result in frequent omission of the radiological consultation with a specialist in radiology, would mean less efficient radiological service with potential legal complications and would tend to create difficulties with national and other organizations requiring supervision of the radiological work by a competent radiologist.

The Radiological Inter-Society Committee is happy to announce the engagement of Mr. Mac F. Cahal, of Wichita, Kansas, formerly Executive Secretary, Sedgwick County Medical Society, as Executive Secretary. Mr. Cahal is a splendid type for the task which the Committee anticipates and has had several years of experience in this sort of work, having been for the past five years Executive Secretary to a large county medical association. Mr. Cahal will represent the interests of radiologists and of radiology at all times and in any place where his presence may be required. The Committee considers this an enormous stride toward its ultimate goal and hopes and confidently expects the financial support of the various radiological societies.

AMERICAN RADIUM SOCIETY

The American Radium Society will hold its Twenty-second Annual Meeting at the Chelsea Hotel, Atlantic City, N. J., on Monday and Tuesday, June 7 and 8, 1937. Dr. Zoe Allison Johnston of Pittsburgh, is the President.

The Program Committee announces the following papers:

The Place of Irradiation in the Treatment of Carcinoma of the Uterine Corpus. By Louis E. Phaneuf, Boston, Mass.

The Selection of Form of Treatment in Uterine Myomas. By Henry Schmitz, M.D., Chicago.

Palliative Treatment of Gynecologic Cancer. By Frank R. Smith, New York City.

Intestinal Injuries Complicating Radiotherapy of Uterine Cancer. By James A. Corscaden, H. H. Kasabach and Maurice Lenz, M.D., New York City.

Review of the Cases of Cancer of the Urethra and Vulva. By Leda J. Stacy, M.D., White Plains, N. Y.

Some Observations on the Results of the Treatment of Breast Carcinoma. By Eugene P. Pendergrass, M.D., and Phillip J. Hodes, M.D., Philadelphia, Pa.

The Treatment of Breast Cancer. By James G. Spackman, M.D., Wilmington, Del.

Artificial Menopause in Carcinoma of the Breast. By Grantley W. Taylor, M.D., Boston, Mass.

Comments upon the Use of Radium and X-Ray in Prostatic Malignancies and Hypertrophy. By Curtis F. Burnam, M.D., Baltimore, Md.

Cancer of the Thyroid in Children. By Hugh F. Hare, M.D., Boston, Mass.

Correlation of Roentgen-Ray and Gamma-Ray Ionization Dosage. By L. Marinelli, M.A., New York City.

Methods of Applying Radium Element in the Form of Needles and Tubes. By George C. Wilkins, M.D., Manchester, N. H.

A Dose Chart for Interstitial Radium Element Needles. By Lawrence Pomeroy, M.D., Cleveland, Ohio.

Protective Shields in Radiation Therapy of Intraoral Cancer. By Andrew Ackerman, D.D.S., New York City.

Organization of Tumor Clinic in General Hospital with Small Supply of Radium. By James S. Gallo, M.D., Patterson, N. J.

Melanoma—Types, Pathology and Management. By George T. Pack, M.D., and Frank E. Adair, M.D., New York City.

Treatment of Epithelioma of the Nasolabial Fold. By Orville Meland, M.D., Los Angeles, Calif.

Radium Therapy of Vernal Conjunctivitis. By H. H. Bowing, M.D., and R. E. Fricke, M.D., Rochester, Minn.

Cancer of the Eyelids. By G. Allen Robinson, M.D., New York City.

The annual banquet will be held on Monday night, June 7, at the Hotel Chelsea. The President, Dr. Zoe A. Johnston, will give a talk on Madame Curie. Edith H. Quimby, M.A., Memorial Hospital, New York, will discuss Radiological Physics.

E. H. Skinner, *Chairman*
Program Committee

FIFTH INTERNATIONAL CONGRESS OF RADIOLOGY

One of the most outstanding scientific events ever to occur in the United States will be held in Chicago in September, 1937, when the Fifth International Congress of Radiology convenes. It will be the first time that the world leaders in the medical and scientific fields of the roentgen ray and radium have met in America. The dates are September 13 to 17, and the meeting place is the Palmer House.

At least 500 distinguished delegates and guests from a score of European countries as well as physicians from Mexico, Canada and Central and South America are expected to attend, with more than 2,000 other delegates and visitors from all parts of the United States.

The annual medical conventions of the leading radiological societies of this country will be merged with the International Congress. These include the American Roentgen Ray Society, the American College of Radiology, The Radiological Society of North America and the American Radium Society.

These international meetings are held every three years. The First International Congress of Radiology convened in London in 1925; the second in Stockholm in 1928; the third in Paris in 1931 (where tribute was paid to the then living Madame Curie, co-discoverer of radium), and the fourth in Zürich in 1934.

These international congresses seek to maintain a continuity of program over the years, and in consequence such vital subjects to the radiologist (and to the general public) as diagnosis and treatment of cancer and many other diseases, and teaching and training in radiology will be on the agenda of this Congress as well as at former meetings. Leaders in other branches of medicine will also take part, as this Fifth International Congress of Radiology will have for its theme "The Unity of Medicine." More than 250 scientific papers will be read at the five day meeting. These will be delivered in each lecturer's own language and will be flashed on screens in English, German and French as the papers are read.

What will probably be the greatest scientific and technical exhibit ever assembled will be participated in by physicians, physicists and manufacturers of radiological equipment.

Dr. A. C. Christie of Washington, D. C. is the President of the Congress. The General Secretary, Dr. B. H. Orndoff, is in charge of headquarters at 2561 North Clark St., Chicago, Ill. Honorary Vice-Presidents are Dr. G. E. Pfahler of Philadelphia, Dr. James Ewing of New York and Dr. W. D. Coolidge of Schenectady, N. Y. On the International Executive Committee are Dr. A. C. Christie of Washington, D. C., Chairman; Dr. C. Thurstan

Holland of Liverpool; Dr. Gösta Forssell of Stockholm; Dr. Antoine Béclère of Paris; Dr. H. R. Schinz of Zürich; Dr. Karl Frik of Berlin; Dr. Mario Ponzio of Florence; Dr. Tamotsu Watanabe of Osaka, Japan; Dr. Heliodoro Tellez-Plasencia of Santander, Spain, and Dr. Gottwald Schwarz of Vienna.

EXCEPTIONAL EDUCATIONAL OPPORTUNITIES AT THE FIFTH INTERNATIONAL CONGRESS OF RADIOLOGY

An unusual opportunity will be offered at the Fifth International Congress of Radiology, September 13 to 17, 1937, Palmer House, Chicago, Illinois, for instruction in certain selected fields of radiology. The courses to be offered are as follows:*

Roentgen Therapy in Cancer

Dr. Henri Coutard, Chief of Roentgen Therapy Service in the Radium Institute, Paris, France.

Radiation Therapy in Gynecology

Dr. James Heyman, Chief of the Department of Gynecology, Radiumhemmet, Stockholm, Sweden.

Problems in Roentgenological Diagnosis

(This is an advanced course for experienced radiologists which will deal with difficult problems of diagnosis selected from the vast material available at the Massachusetts General Hospital.)

Dr. George W. Holmes, Clinical Professor of Roentgenology, Harvard University Medical School; Director of Radiological Department, Massachusetts General Hospital, Boston, Massachusetts.

(Dr. Holmes will be assisted by his associates, Dr. Aubrey O. Hampton, Dr. Richard Schatzki and Dr. Richard Dresser.)

The Fundamentals of Roentgen and Radium Therapy

Prof. Dr. Hermann Holthusen, Professor in the University, Chief of the Radiological Service, St. George Hospital, Hamburg, Germany.

Roentgen Diagnosis in Gastroenterology

Dr. B. R. Kirklin, Professor of Radiology, University of Minnesota, Graduate School of Medicine; Chief of the Department of Radiology, Mayo Clinic, Rochester, Minnesota.

(Dr. Kirklin will be assisted in this course by other radiologists who are outstanding in this special field.)

Special Problems of Radiation Therapy Relating Particularly to Treatment of Cancer of the Cervix and Cancer of the Breast

(This course is directed especially to the needs of the specialist in radiology and will be found of particular interest to radiologists located in the smaller centers of population.)

Dr. Edwin A. Merritt, Clinical Professor of Radiology, Georgetown University Medical School; Chief Radiologist, Warwick Memorial Clinic and Garfield Memorial Hospital, Washington, D. C.

The Diagnosis of Brain Lesions

Dr. Merrill C. Sosman, Assistant Professor of Roentgenology, Harvard University Medical School; Chief of Radiological Service, Peter Bent Brigham Hospital, Boston, Massachusetts.

Elementary Physics of Radiation

Dr. James L. Weatherwax, Philadelphia General Hospital, Philadelphia, Pennsylvania.

Each of the above courses will occupy four hours; that is, one hour on each day of the Congress, September 14 to 17 inclusive. The courses will be given at an hour when they will not conflict with other activities of the Congress, namely eight to nine in the morning.

Each of the courses will be given in English and will be open to between fifty and one hundred members of the Congress who will register specifically for any one course. Those who have already made application for membership in the Congress may register for one of the courses by writing to the General Secretary, 2561 N. Clark Street, Chicago, Illinois. Future applicants for membership in the Congress may register when they submit their applications. Registrations for the courses will be accepted in the order of their receipt at the Chicago office.

All courses will be given without extra charge to members of the Congress who register for them in the manner indicated above. It is desired that registration be made at as early a date as possible.

* Attention is directed to the addition of the course by Dr. Heyman since the announcement of these courses in the March number of the Journal.

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DEPARTMENT OF TECHNIQUE

Department Editor: Robert B. Taft, M.D., M.S., 105 Rutledge Ave., Charleston, S. C.

AN IMMOBILIZING DEVICE FOR ROENTGENOGRAPHY OF THE CHEST IN INFANTS*

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CLEVELAND, OHIO

THE value of roentgenograms of the chest taken in the upright position is well recognized, and every department of roentgenology has facilities for taking such roentgenograms of adult patients. However, due to the fact that infants and small children constitute a small percentage of the patients in many clinics, expensive or cumbersome apparatus for handling them is not warranted. Nevertheless, if such patients are to be cared for, an attempt should be made to obtain the best possible films.

Fig. 1. The immobilizing device placed on the end of the roentgenographic table with a patient in the upright position.

To be satisfactory, any device for upright chest roentgenography of small patients should meet the following requirements:

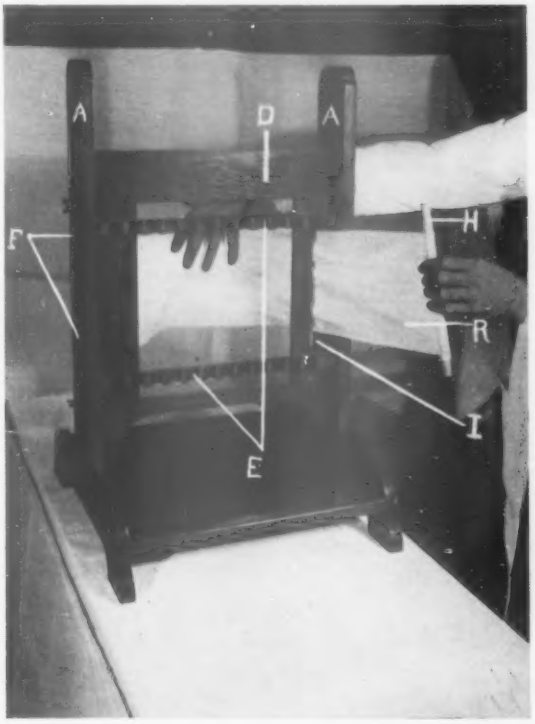

Fig. 2. The posterior aspect of the immobilizing device showing the wooden cassette frame, *D*, which may be moved up or down between the two uprights, *A*, for the length of the slots, *F*. The wooden rod, *H*, at the free end of the restraining band, *R*, is passed around the back of the patient, through the slot, *I*, at the side of the cassette, and placed in the notches, *E*, according to the size of the patient and the tension desired.

1. The chest should be efficiently immobilized in any desired angle of rotation.
2. The device should be sufficiently

* From the Department of Roentgenology, Cleveland City Hospital and Western Reserve University, Cleveland.

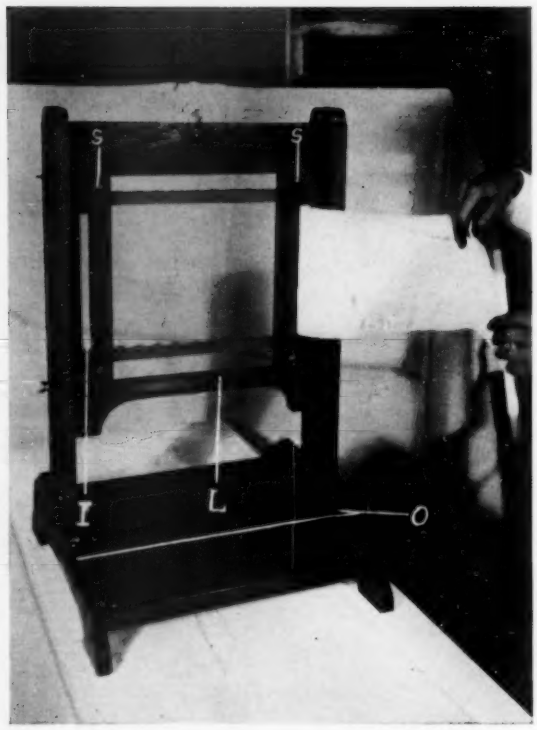

Fig. 3. The anterior aspect of the immobilizing device showing the inset in the wooden frame, *L*, into which the cassette is placed, the metal strips, *S*, which secure the cassette (four are shown although only two are essential) and the offsets, *O*, at the sides of the platform which allow the patient's legs to be extended to either side for lateral films of the chest.

flexible to accommodate infants and children of different sizes.

3. The time and personnel required for its use should be minimal.

Numerous immobilizing devices have been designed. Wimberger,[5] in 1922, constructed a box with two uprights on either end holding slotted arm rests which were adjustable as to height. The distance between the uprights was also adjustable according to the size of the patient who was seated on the box between them with his arms in the slots and his legs over the edge. Viethen[4] used the same arrangement, but added an overhead frame from which upward traction was exerted on a wide collar placed around the patient's neck. He also passed a band in front of the patient's legs to keep them from being drawn upward. Pancoast and Pendergrass[3] seated their small patients on a board placed across the arms of a wooden chair, the back of which was converted into a cassette holder with an immobilizing band attached. Kohn and Koiransky,[2] in 1931, presented a device somewhat similar to the one described in this article except that their frame was made of iron piping, and the immobilizing band was tightened by means of a commercial iron ratchet, all of which added considerably to the weight and expense of the apparatus. The most elaborate machine of all was designed by Wood,[6] and consisted of a high metal chair with a suspension fabric seat containing holes through which the infant's legs were placed. The infant was immobilized by a flexible lead band placed about the hips, and a regular immobilizing band around the chest. By means of a turn-table device built into the frame, the patient was rotated to any desired angle. Bowen[1] had his infant patients swathed and bound to a board which was then placed in a frame or in any desired position for the roentgenogram.

The device presented in this article uses many of the principles of those described above. In addition, it offers the following advantages:

1. The apparatus weighs only 15 pounds, when constructed of oak, and may easily be placed on the end of the roentgenographic table or on a hospital rolling stretcher. When not in use, it may be suspended on a hook placed in some part of the roentgenographic room which would not otherwise be utilized.

2. The cost of the materials is less than $5.00, and the device can readily be made by any competent carpenter, using the accompanying photographs and blue print.*

The restraining band is made of heavy muslin, and measures 8×30 inches. Its fixed end is held under the brass plate

* I am indebted to Mr. Joseph Gebo, the hospital carpenter, for his aid in constructing this immobilizing device and for furnishing the blue print.

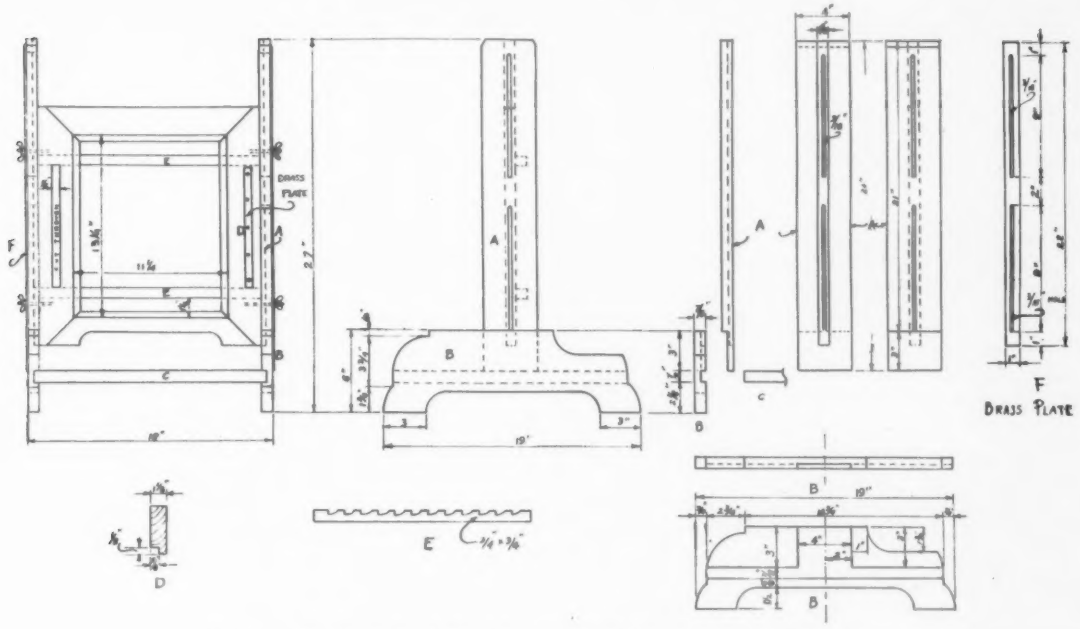

Fig. 4. Photograph of the blue print of the immobilizing device.

(Fig. 4), or, to facilitate replacement, may be held between two brass plates by thumb screws. A round wooden rod measuring $\frac{1}{2} \times 10$ inches is passed through a sewed-in fold in the free end of the restraining band (Fig. 2).

The wooden frame is made to accommodate a cassette measuring $11\frac{1}{8} \times 13\frac{1}{8}$ inches which holds a 10×12 inch film. To hold the cassette more securely, flat metal strips, each measuring $\frac{1}{2} \times 1$ inch with a hole drilled in one end, may be attached by a screw on each side of the frame next to the tube side of the cassette (Fig. 3) and turned across the edges of the cassette after it is in place. A smaller wooden cassette holder may also be thus secured if it is found desirable to use smaller films.

Children are seated on the platform with their legs extended beneath the frame (Fig. 1). Infants are held against the cassette by the restraining band and supported by the nurse who accompanies them.

This immobilizing device has been in use in the department of roentgenology for several months, and has proved to be of great value in obtaining better chest roentgenograms of infants and small children.

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ABSTRACTS OF ROENTGEN AND RADIUM LITERATURE

ROENTGEN DIAGNOSIS

ABDOMEN

Novati, Giulio Calchi. Contributo radiologico alla diagnosi di tumore primitivo del fegato. (Roentgen contribution to the diagnosis of primary tumor of the liver.) *Radiol. med.*, Jan., 1936, *17*, 21–26.

A man aged sixty-five was sent to the hospital with a diagnosis of cirrhosis of the liver. Roentgen examination showed nodules protruding from the upper surface of the liver and pushing the diaphragm upward. Successive examinations showed rapid increase in the size of the liver. To clarify the diagnosis further a pneumoperitoneum was performed. In addition to great enlargement of the liver it showed polycyclic shadows of various sizes in the lower and lateral surfaces of the liver, evidently pathological masses protruding from the surface of the liver. It showed nothing in regard to the upper surface because of the strict adhesions between the diaphragm and upper surface of the liver. An examination was then made after the introduction of 100 c.c. thoriofanin.

The pneumoperitoneum proved much more valuable in this case than the thorium examination. The latter showed only a rather pale liver shadow with irregular areas of density greater than that of the normal liver. The only thing that could be gathered from this examination was that there were profound pathological changes in the liver. The author thinks hepatography with thorium is apt not to be very successful in conditions in which the reticulo-endothelial system of the liver is seriously injured. He thinks pneumoperitoneum has been too much neglected lately in favor of other methods less simple and less safe. It is by no means certain that the presence of thorium in the liver does not in the long run seriously injure the organ.—*Audrey G. Morgan.*

Ratti, Arduino. In tema di epatografia. (Hepatography.) *Radiol. med.*, Jan., 1936, *23*, 1–20.

The author discusses the diagnostic value of roentgen examination of the liver with the use of a colloidal suspension of thorium dioxide as a contrast medium. The particles of thorium, injected intravenously, are caught and held by the reticulo-endothelial cells of the liver and spleen. The chief condition in which he has found this method of diagnosis valuable is in liver metastases of malignant tumors. The thorium is not retained by the metastatic nodules and therefore clear spots appear in the roentgenogram at the site of the nodules. The method is of considerable diagnostic value and may aid in deciding whether operation is indicated in cases of malignant tumor. There are cases in which there seems to be diffuse injury of the liver rather than metastatic nodules in which the whole liver shows slight contrast. A number of cases are described in which diagnosis has failed for this or other reasons. Nevertheless these cases are relatively rare. Differential diagnosis from gummata is difficult. However, clinical differentiation should be possible. A positive finding is of greater diagnostic value than a negative one.

Care is necessary in technique as with too dense an impregnation with thorium the metal may enter the metastatic nodules and with too little impregnation there may not be enough contrast to give clear pictures. Ratti thinks the impregnation should be brought about gradually to get the best results and therefore he fractionates the dosage and takes a number of roentgenograms. He gives 10 to 15 c.c. a day for several successive days up to a total of 60–75 c.c.

There has been considerable discussion as to whether or not the method is injurious. It has been sufficiently demonstrated that the immediate effects are not harmful but it seems possible that the retention of thorium in parenchymatous organs might eventually have bad effects. Cases have been under observation for some years, however, without injury. Naturally the method should be used only for patients who are in fairly good general condition. —*Audrey G. Morgan.*

Wright, A. Dickson. X-ray appearances produced by congenital cystic dilatation of the common bile duct. *Brit. J. Radiol.*, April, 1935, *8*, 227–230.

The case reported was studied to determine if there were any characteristic roentgen appearances which would help in the differentiation of these cases. Excretion urography showed a hydronephrosis, not sufficient in degree to produce the tumor. Cholecystographic study showed a gallbladder of a peculiar comma-shape, due to its being flattened over the top of the cyst. There was, in addition, faint calcification of the cyst wall where it was in contact with the gallbladder. There was normal concentration of the dye. A peculiar lyre-shaped calcification, corresponding in position to the hepatic ducts, was noted and felt to be due possibly to calcification within the walls of these ducts.—*W. R. Brooksher.*

Bell, Kenneth R. Cholecystography: the advantages of the intravenous administration of the dye. *J. Med. Ass. Georgia*, Feb., 1935, *24*, 52–55.

Poor gallbladder visualization following oral administration of the dye is due to non-absorption, with the frequent occurrence of nausea, vomiting and diarrhea, causing the loss of an unknown quantity of the dye. In oral cholecystography, when faint or non-visualization occurs, the question is always: "Is it due to pathology or to non-absorption?"

The intravenous method is not only more accurate, but also causes fewer reactions. It further offers the opportunity for the simultaneous performance of the liver function test, a decided advantage to the surgeon. The only contraindications to the method are those for any form of intravenous medication, viz., advanced heart disease, nephritis, allergy, marked debility, acute illness of any type and very low blood pressure. Very slow gravity administration in very dilute solution is the preferable mode of injection.—*W. R. Brooksher.*

Engelstad, Rolf Bull, and Römcke, Olaf. The diagnosis of pancreas stones. *Acta radiol.*, 1936, *17*, 79–84.

Roentgen examination has heretofore been considered of minor importance in diagnosing diseases of the pancreas. But now that Engel and Lysholm have shown that tumors of the pancreas can be diagnosed by roentgen examination this method will probably be used more freely in the diagnosis of these diseases.

The authors describe 2 cases in which stones of the pancreas were diagnosed by roentgen examination. One was in a workman aged thirty-eight and the other in a businessman aged thirty-two. Both showed pain and symptoms indicating pancreatitis. Roentgen examination showed a collection of stone shadows in the region of the pancreas. The outline of the collection of stones corresponded to the outline of the pancreas. In order to remove all doubt, a duodenal sound filled with contrast medium was inserted. It encircled the stone shadows, showing that they really lay in the pancreas.

The possibility of stones of the pancreas should be borne in mind in making examinations for obscure abdominal pain.—*Audrey G. Morgan.*

Goyena, Juan Raul. Diagnóstico clínico del cáncer del páncreas. (Clinical diagnosis of cancer of the pancreas.) *Bol. Inst. de med. exper. para el estud. y trat. del cáncer*, Dec., 1934, *11*, 762–779.

Malignant tumors, and especially cancer, of the pancreas are of relative frequency and their diagnosis may under certain circumstances offer great difficulty. The author's group includes 26 cases of carcinoma and one case of sarcoma of the pancreas, out of a total of 605 malignant tumors of all localizations, which indicates an incidence of 4.29 per cent. From a diagnostic standpoint, the tumors may be placed in two groups: (*a*) Cancer of the head of the pancreas. This localization is characterized by a series of manifestations which may be placed under the heading of pancreatic-biliary syndrome. The chief manifestation, as a rule, is retention icterus which commences insidiously and marches progressively towards an ever increasing jaundice of the tissues. To this are added the manifestations in connection with an insufficiency of the digestive function of the pancreas. After discussing the various clinical symptoms associated with such manifestations and especially the differential diagnosis from lesions producing a similar picture, as, for example, stone in the choledochus, chronic pancreatitis, etc., the author stresses the value of the roentgen examination which, as a rule, leads to the following findings: Because of the position of the head of the pancreas within the duodenal frame, usually an enlargement of this frame is encountered which depends on the progressively increasing size of the tumor. This appearance is so characteristic that a

diagnosis is frequently made with great precision. (*b*) Cancer of the body of the pancreas. In contradistinction to the former, this type of localization of the carcinoma is characterized by the so-called solar pancreatic syndrome. Here the chief manifestation is pain due to the pressure effect on the solar plexus, and icterus does not occur until in the later stages. Depending on the affection of the neighboring organs, one may encounter other clinical forms such as the forms characterized by the phrenic syndrome or by the dyspeptic disorders or the nondolorous forms with ascites and anasarca, the pseudo-aneurysmal form, the melanodermic, the cachectic and finally the febrile form. The roentgen diagnosis is based on the effect of the tumor on the neighboring organs, such as pressure on the various parts of the digestive tract, as, for example, a pressure defect of the antrum and distant portion of the greater curvature or pressure defect on the colon or, if the carcinoma has invaded the entire pancreas, an enlargement of the duodenal frame, as already described for carcinoma of the head of the pancreas.

It is apparent from the aforesaid that the carcinoma must be in a rather advanced stage to produce pressure on the neighboring organs, but even so, not infrequently it will be impossible to arrive at correct diagnosis despite most minute clinical and roentgenologic investigations. In such instances exploratory laparotomy is justified as the only means affording a proper way for diagnosis and the institution of an adequate treatment which may eventually lead to a cure.—*T. Leucutia.*

Casati, Annibale. Le nicchie con lacuna e le immagini ad anello nelle ulcere gastriche e duodenali. (Niches with a lacuna and ring images in gastric and duodenal ulcers.) *Radiol. med.*, April, 1936, *23*, 227–239.

The roentgen images in gastric and duodenal ulcers may be different from the classical niche. There are two that have been described particularly and attempts made to account for them anatomically. In the one there is a niche with a small central negative lacuna and in the other a filiform ring without a niche. The author describes and illustrates with roentgenograms 2 cases showing these atypical pictures. In one of them there was quite a large clot adherent to the base of the ulcer by means of a pedicle but in the other there was no trace of any central anatomical structure to account for the appearance. Many authors are inclined to attribute these pictures to the presence of clots in the ulcer but the presence of such clots is unusual and the author does not believe that any of the suggested anatomical explanations are the true cause of the images. He thinks they are due in great part to variations in technique, such as compression, small quantity of contrast medium and the incidence of the rays. The ring images may indicate an ulcer that is increasing in depth and tending to perforation. —*Audrey G. Morgan.*

Hodgkins, E. M. Primary carcinoma of the jejunum with report of two cases. *New England J. Med.*, March 5, 1936, *214*, 477–480.

The literature is briefly reviewed and the pathology is discussed. In the 2 cases reported, the lesion was discovered at operation; in the first, while resecting a portion of the stomach for an obstructing ulcer; in the second, on exploratory laparotomy for intestinal malignancy.—*W. R. Brooksher.*

Orley, Alexander. The roentgenological diagnosis of the diseased appendix. *Brit. J. Radiol.*, August, 1935, *8*, 487–496.

The author briefly discusses the history of roentgen diagnosis of the diseased appendix and comments in detail upon the technical factors of the examination. The different types of normal appendices are presented, describing their mobility, motility, filling and emptying. The remote signs are mentioned. Tenderness, abnormal filling, fixation and stasis are considered direct diagnostic signs. Three types of fixed appendices are mentioned: (1) fixed along the cecal wall; (2) fixed by its tip only to the pelvic wall, and (3) the one seen permanently at the outer side of the cecum. Fixation and kinking are considered of clinical importance only when associated with disturbed function, especially if this is manifested as tenderness. Non-visualization is emphasized and may be due to: (1) anatomical lesions; (2) spasm of the proximal portion; (3) very rapid emptying; (4) blocking of the proximal portion, and (5) the presence of non-opaque hard fecal matter within the lumen.—*W. R. Brooksher.*

Bowcock, Harold. The internist's attitude toward unusual x-ray findings in the appendix area. *South. M. J.*, May, 1936, *29*, 497–499.

Prolonged retention of barium in the appendix over days and weeks is discussed, attention being directed to the fact that most instances are overlooked due to termination of the roentgen examination at the twenty-four or forty-eight hour period. Proof of the assumption that this condition is either a rather uncommon but normal variant or that it is pathologically significant must depend upon lengthy observation in patients presenting this finding. Presenting 8 case reports, the author believes that retention is a physiologic abnormality, having in some cases no demonstrable pathologic significance. In the presence of unexplained gastrointestinal symptoms, of which persistent tenderness is the most important, it should be regarded as a noteworthy finding.—*W. R. Brooksher.*

Popp, L. Starea actuală a examenului radiologic in apendicita cronică. (The present status of roentgen examination in chronic appendicitis.) *Cluj. med.*, 1935, *16*, 414–429.

After a detailed review of the various methods collected from the medical literature and from his own personal experience, the author establishes the following roentgen signs as characteristic of chronic appendicitis. I. *Sure signs.* (1) Appendices with non-filling or with a filling of the small proximal portion represent appendices pathologically obliterated, especially if associated with tenderness on manipulation. (2) The filiform appendix, if constantly present, indicates a diffuse sclerosis of the chronically inflamed appendicular wall. The same picture is encountered, however, if the tip of the appendix is fixed to an immobile organ, as for example, the iliac fossa or the tube. Some differentiation may be obtained from the fact that the point of tenderness in these latter is usually at the tip of the appendix whereas in a sclerosed appendix the tenderness extends through the entire length. (3) Appendices with irregular lumen in which constant large ectasias alternate with constrictions are doubtless pathological. The ectasias represent sequelae of atrophy of the wall whereas the constrictions are a sign of sclerosis. (4) A homogeneous ampulla-like ectasia of the appendicial lumen is pathological and indicates a diffuse atrophy of the wall. (5) Persistent kinkings represent signs of periappendicular adhesions. (6) The constant and unalterable lateral situation of the appendicular tip is a sure sign of periappendicular and especially periapical adhesions. (7) The fixation of part or of the entire appendix at repeated examinations is likewise a sure sign of adhesions. (8) The abnormal position of the appendix with the tip upwards, retrocecal, partially retrocecal or medial dorsal is, as a rule, due to adhesions between the appendix and cecum. (9) A defect in the shadow of an ectatic appendix represents a coprolith. (10) The torsion of the appendix with the inferior pole upward must be attributed to adhesions which have developed secondarily to a chronic appendicitis.

II. *Probable signs.* These are: (1) Tenderness on palpation of the appendix. (2) Isolated stasis of barium at the tip of the cecum, persisting for several days after the evacuation of the colon. This sign, however, may be encountered also in chronic constipation and therefore has only a relative value. (3) Isolated stasis of barium within the appendix after the evacuation of the colon. This sign has also only a relative value unless it persists for a period of five days in spite of the administration of repeated purgatives. (4) Reflectoric functional disturbances of the digestive tube such as pyloric and duodenal spasms, hyperkinesia of the terminal ileum, spastic constipation, spastic haustration of the cecum and the phenomena of irritation as observed in the relief image of the colon and especially of the cecum. To these, finally, may be added the temporary spasm of the cardia, aerophagy, vagotonic phenomena with hypersecretion, and reflectoric gastric hyperkinesia.—*T. Leucutia.*

Bell, Joseph C. The roentgen-ray examination of the colon in the study of amebiasis. *South. M. J.*, May, 1936, *29*, 462–471.

In cases described as subacute amebic dysentery, the author has observed an irregular narrowing of the lumen of the various portions of the colon sometimes associated with a palpable mass. The abnormally small, often irregular cecum, and the unusual degree of incompetence of the ileocecal valve as described by Webber, was noted. The only differential point between chronic amebic infections and the usual type of chronic ulcerative colitis has been the rather characteristic cecal deformity of the former.—*W. R. Brooksher.*

Louria, Milton R., and Rothstein, Emil. Spontaneous gastro-colic fistula. *Am. J. Digest. Dis. & Nutrition*, 1936, *2*, 756–758.

Report is made of a case of spontaneous gastrocolic fistula resulting from the perforation of a gastric carcinoma in the transverse colon. A clinical diagnosis was based upon the fecal character of the vomitus, a practically pathognomonic sign. Other than the roentgen study, the use of colored dyes is of value in corroboration.—*W. R. Brooksher.*

GYNECOLOGY AND OBSTETRICS

Johnson, Clayton R. X-ray examination of the obstetrical patient. *Western J. Surg., Obst. & Gynec.*, Jan., 1936, *44*, 21–27.

Details of the author's stereoscopic method of examination, originally published in 1929, are recounted. From the stereoscopic films, a phantom image is reconstructed from which, by means of the stereoroentgenometer, the true conjugate or any desired diameters of the pelvis or fetal head may be measured.—*W. R. Brooksher.*

Iles, A. J. H. Labor obstructed by spondylolisthesis. *Brit. J. Radiol.*, 1935, *8*, 659–660.

In a prolonged delivery roentgenograms showed a deformed pelvis with a vertical sacrum and beginning spondylolisthesis, the fetal head being partly obstructed by the sacrum but more so by the fifth lumbar vertebra. Cesarean section was performed.—*W. R. Brooksher.*

GENITOURINARY SYSTEM

Barclay, I. B., and Baird, J. B. Excretion urography, based upon 385 cases investigated in a large general hospital. *Brit. J. Radiol.*, April, 1935, *8*, 201–216.

A study of 385 consecutive cases shows that excretion urography is a reliable, safe and useful procedure, not only for the investigation of intrinsic lesions of the genitourinary tract, but also for its value in the identification of extra-urological conditions. The functional activity, the anatomy and the dynamics of the tract are well visualized. At least three roentgenograms, made three, ten and thirty minutes after the administration of the solution, are required for accurate interpretation.—*W. R. Brooksher.*

Moore, Thomas D. The limitations of intravenous urography. *South. M. J.*, March, 1936, *29*, 242–247.

Outside of the field of urology too much reliance is being placed upon intravenous urography, not only in determining the anatomical outline of the urinary tract, but also as a renal functional test. With failure of visualization in either renal area, a complete urological study should be made. Poor or absent visualization may be due to: (1) temporary or reflex inhibition of function; (2) incomplete filling; (3) hypersecretion or hypermotility with little or no medium retained; (4) non-calculous obstruction at the renal outlet or along the course of the ureter; (5) temporary impairment of function due to nephritis and occasionally to toxic states, and (6) true absence of function. The procedure is most useful and dependable in the following conditions: (1) in the identification of doubtful shadows in the region of the upper urinary tract; (2) in the determination of renal and ureteral anomalies; (3) in proving or disproving the presence of stasis; (4) as a differential diagnostic point, the observation that both kidneys are of normal outline and function renders unnecessary a cystoscopic examination, and (5) in cases where instrumentation is inadvisable. The information furnished is inadequate in the presence of gross hematuria or pyuria, for the detection of early renal tuberculosis or neoplasms, or for the recognition of polycystic disease with its attendant poor function. The need for an exact technique is emphasized. In a group of 150 patients subjected to the examination by the author, approximately two-thirds required no further urographic study, but in one-half of these the diagnosis was negative. The remaining one-third required cystoscopy with or without retrograde pyelography, revealing pathological conditions in all but 7, which the urogram had failed to completely disclose. Lower urinary tract lesions will be frequently overlooked unless resort is had to cystoscopy. As a renal functional test, it may be relied upon if the function is normal. It is decidedly unreliable as an indicator of impaired or absent function. —*W. R. Brooksher.*

Ribbing, S. La stratification des liquides opaques dans l'urographie. (Stratification of the opaque liquid in urography.) *Acta radiol.*, 1935, *16*, 716–718.

The author formerly believed that in intravenous pyelography the opaque urine did not stratify beneath the urine which does not contain any contrast. He has since had occasion to change his mind and admits that such

stratification does take place. This is illustrated by the roentgenograms of a case of hydronephrosis.

In retrograde pyelography this tendency of the urine to stratify is of value in studying the anatomical condition of the ureter. Often a picture of the ureter cannot be obtained in the usual dorsal decubitus because of the pain it causes the patient and the risk of injecting too great an amount of fluid. On turning the patient in ventral decubitus, opacity of the ureter can often be obtained. Because of the ventral position of the ureter in front of the psoas muscle, the opaque liquid descends into the ureter and fills it while the urine that does not contain any contrast medium rises into the pelvis and fills it. If the ureteral sound is removed in this position and a roentgenogram taken immediately, good images of the ureter are obtained. The author believes this is superior to Chevassu's method of filling the opening of the ureter with an olive-tipped sound, as the latter is not without danger.—*Audrey G. Morgan.*

Schiffer, Ernst. Füllungsdefekt bei retrograder Pyelographie vorgetäuscht durch einen Nierenkelchkrampf. (Filling defect in retrograde pyelography simulated by spasm of the kidney calyces.) *Acta radiol.*, 1936, *17*, 93–98.

The author describes a case in a man aged twenty-eight who had a severe attack of pain in the left kidney region radiating to the scrotum. A retrograde pyelographic examination showed no filling of the calyces on this side, though the rest of the pelvis was well filled. The examination was made during an attack of colic during which a stone was passed. The discrepancy between the clinical and roentgen findings suggested another examination. The young man was in good health aside from the attack of colic with moderate hematuria. He had had no elevation of temperature, no loss of weight and no hematuria except during this pain so it hardly seemed that there could be any serious kidney disease. Examination five hours later when he was free of pain showed normal filling of both calyces and pelvis.

The case shows that in kidney colic muscle spasm may cause a roentgen picture that might very readily be misinterpreted.—*Audrey G. Morgan.*

Butler, Edmund, Sullivan, John R., and Birnbaum, W. Radiographic evidence an indispensable aid in the diagnosis of intraperitoneal rupture of the bladder. *Western J. Surg., Obst. & Gynec.*, 1935, *43*, 410–413.

The roentgen ray assists in the differential diagnosis: (1) the flat film will show the renal outline, frequently blurred by perinephritis; (2) excretion urography will show absence of the usual rounded bladder shadow; (3) cystograms (sodium iodide) will show escape of the opaque fluid into the general pelvic cavity, and (4) following air injection of the bladder, the air may show beneath the diaphragm.—*W. R. Brooksher.*

Hyman, Abraham. Suprapubic cystotomy with excision and irradiation in the treatment of malignant tumors of the bladder. *Am. J. Surg.*, April, 1935, *28*, 5–22.

Suprapubic cystotomy is preferable to cystoscopic implantation of radium for the following reasons: (1) it is difficult to ascertain cystoscopically the exact extent and character of the neoplasm; (2) the degree of infiltration of the bladder wall can only be definitely determined by a suprapubic approach, and (3) the tumor can be perfectly visualized, insuring accuracy in the distribution of the radon seeds. The operative technique for this procedure and for the more radical operation of excision of the tumor is detailed.—*W. R. Brooksher.*

SKELETAL SYSTEM

Sorokin, F. F. Zur Frage der Synostosis Radio-Ulnaris. (Synostosis of the radius and ulna.) *Acta radiol.*, 1936, *17*, 191–199.

About 180 cases of synostosis of the radius and ulna have been described in the literature. The author gives a brief description with roentgenograms of 3 cases. This anomaly can now be diagnosed by roentgen examination and in no other way. The chief clinical symptom is lack of pronation and supination of the elbow joint with preservation of flexion and extension. It is difficult or impossible for the patient to perform any act that requires supination. There are two forms of the anomaly. In the first there is a synostosis of the proximal ends of the radius and ulna for a distance of 2.5 to 6 cm. This occurs early in embryonic life before the forearm bone has become differentiated into a radius and an ulna. There is no head of the radius and the radius passes immediately into

the coronoid process of the ulna which is larger than normal. Only the ulna connects with the humerus. In the second type the synostosis takes place after the radius and ulna have been formed; the elbow joint is normal. The head of the radius is deformed and often displaced backward and upward. Often there are exostoses with limitation of flexion and extension. In both forms the arm is held in a position of pronation or midway between pronation and supination. This anomaly is often associated with others, such as syndactylia, adactylia, polydactylia, congenital luxation of the hip, flat foot, Madelung's deformity, etc.

There is apt to be atrophy of the inactive pronator and supinator muscles which sometimes furnishes an indication for operation. But as the muscles are insufficient the synostosis is apt to recur.—*Audrey G. Morgan.*

Ionescu, V. Formaţiune osoasă rară consecutivă unei răniri prin schije de obuz. (A rare osseous formation as a sequel to a grenade wound.) *Bul. Soc. de radiol. şi electrol. med. din România*, No. 2–3–4, 1935, *4*, 14–20.

This article represents a very unusual case report dealing with the formation of an entire new bone along the track through which a grenade splinter passed. The case is that of a man, aged fifty-six, who suffered injury during the war. A grenade splinter entered in the left gluteal region and, after it fractured the ischium, traversed through the muscles of the thigh downward as far as the midportion of the shaft of the femur where it was stopped by the bone. Infection of the wound followed which necessitated a surgical intervention and an immobilization of the patient for a period of three months. Following the healing of the wound the patient continued to limp, although he had no pain or other symptoms, and this condition has remained practically unchanged until the present date of examination. The roentgenogram now reveals an osseous new formation which connects the ischium with the midportion of the femur, having the same thickness and rounded appearance as the shaft of the femur itself. There is no doubt that this osseous new formation has developed along the path which the splinter passed. In the author's opinion, it is the result of three factors: (1) a surplus of calcium in the blood (predisposing cause); (2) irritation of the muscular parts and of the periosteum of the femur by the traumatism caused by the passage of the splinter and the consecutive infection, especially since small particles of bone from the fractured ischium were strewn along the entire path of the splinter (provoking cause), and (3) the long immobilization of the patient following the injury (favoring cause).—*T. Leucutia.*

Stenström, Bo. Über Marmorskelette. (Marble skeleton.) *Acta radiol.*, 1936, *17*, 140–151.

Albers-Schönberg about thirty years ago described a peculiar bone disease consisting of diffuse osteosclerosis and marked fragility of the bones associated with anemia.

The author describes a case which he thinks should be classified with this disease though it differed from it in some points. The patient was a man aged fifty-eight who had no personal or family history of bone disease. He had worked a long time as a waiter and had not been exposed to toxic substances that injure bone. For three or four years he had had digestive disturbances; for the past year he had been pale and anemic and exhausted and it was for this reason that he came for examination. He showed a certain amount of enlargement of the liver and spleen. He weighed 90 kilograms, part of it doubtless due to the condition of the bones. There was marked sclerosis of practically all of the bones of the skeleton. The marrow cavities were narrowed in the long bones and in some cases occluded entirely. This had doubtless injured the marrow and led to the anemia. He had never had any fractures and there were no signs of endocrine disturbance. The sella turcica was normal and the thyroid was also normal. There was no calcification of the ligaments and tendons and no very severe arteriosclerosis. The disease is generally fatal and it proved so in this case. Autopsy was not permitted. The bone growth in this case was endosteal. There was no evidence of periosteal proliferation and the circumference of the bones was not increased.

The most difficult differential diagnosis in this case was from metastasis of an osteoplastic carcinoma. The extent of the changes, however, and the fact that no primary tumor could be demonstrated argued against tumor metastasis. The rapidity of sedimentation of the erythrocytes was increased to some extent—about 20 mm. to the hour—which, however, may have been due to the anemia. In a carcinoma with

such extensive metastases it would have been increased much more. There were no lung metastases and no real cachexia.—*Audrey G. Morgan.*

Funsten, Robert V., and Kinser, Prentice. Osteochondritis dissecans as related to trauma. *South. M. J.*, March, 1936, *29*, 262–266.

The authors report 23 cases of osteochondritis dissecans, 17 of which gave a definite history of trauma to the involved joint. One spent many hours daily working on his knees and one case was associated with rupture of the internal semilunar cartilage. Typically, the roentgenogram shows involvement of the inner femoral condyle. Cases of osteochondritis dissecans of the carpal scaphoid and of the semilunar, apparently the first recorded, are reported.—*W. R. Brooksher.*

Hansen, Arild E. Influence of viosterol and parathyroid extract on mineral metabolism in osteogenesis imperfecta. *Am. J. Dis. Child.*, July, 1935, *50*, 132–157.

This study deals primarily with the mineral exchanges of the body in osteogenesis imperfecta, particularly as these exchanges are affected by such factors as the administration of parathyroid extract and of massive doses of vitamin D. The underlying purpose of the investigation was to gain some insight into the nature of this little understood disturbance in osseous development, and to ascertain whether or not the well-known chemical regulators of calcium and phosphorus metabolism are capable of influencing the course of the disease to any extent.

The effects of feeding enormous doses of viosterol and of administering parathyroid extract subcutaneously were studied in the same two patients. Under standard conditions in the control period, both patients exhibited a deficiency in the retention of calcium, phosphorus and magnesium. No abnormality was discovered in reference to other features of the mineral metabolism during this period. The most significant response to large doses of viosterol was the induction of a negative balance for most of the minerals, notably for calcium and phosphorus. The metabolism of nitrogen and sulphur underwent little, if any, change. The urinary output of calcium and phosphorus tended to increase, while the fecal output of these elements was decreased. The influence of viosterol persisted for several days after the medication was discontinued.

Parathyroid extract likewise caused an excessive output of calcium, phosphorus, magnesium, potassium and sodium. Its immediate effect was more marked than that of viosterol. The urinary tract was again the chief pathway for the increased excretion, the absolute losses by way of the intestinal tract increasing but slightly. Unlike viosterol, parathyroid extract had no sustained influence on the mineral exchange. A definitely positive balance for the chief elements was promptly re-established after withdrawal of the hormone.

The significance of the difference in response of the patients with osteogenesis imperfecta as compared with those of normal persons was not apparent. Roentgen examinations of the bones made periodically showed no definite change during the course of the study. The phosphatase activity of the blood plasma was found to be normal during the control phase of the study but was diminished definitely after the administration of parathyroid extract and of massive doses of viosterol.

While it cannot be concluded, Hansen states, from the data he obtained, that hyperfunction of the parathyroid glands is a factor in the pathogenesis of osteogenesis imperfecta, it is obvious that an extract of these organs, or large doses of the similarly acting viosterol, only accentuates the disturbance already present and therefore should not be employed therapeutically.—*R. S. Bromer.*

Speed, Kellog. The unsolved fracture. *Surg., Gynec. & Obst.*, Feb. 15, 1935, *60*, 341–352.

In fractures of the neck of the femur the principal points of interest have been in the behavior of the head of the bone after fractures, the changes developing in it or its covering cartilage resulting in interference with blood supply, aseptic necrosis, revascularization and substitution for dead bone by newly formed bone. Roentgenologic investigation sheds much light on the progress of the case. One can determine the amount of regional atrophy about the fracture, the probable viability of the head as evidenced by density changes and mottling, along with changes in configuration indicating flattening, collapse or cartilage changes.

Phemister's statistics are quoted in which 49

patients were reported, of whom 17 had femoral heads which were alive, 8 with union and 9 with non-union. There were 32 cases of complete or partial necrosis of the head with union present in 4, and non-union in 28. Some instances of this fracture in relatively young individuals lead to dead femoral head and non-union; in the adolescent, death and degeneration of the femoral head in appearance strikingly similar to Legg-Perthes' disease may come on months after an apparent bony healing by epiphyseal separation.

The author employs the Whitman method of closed reduction employing a plaster dressing to maintain reduction. The average percentage of union is probably higher than it was a hundred years ago, but in comparison to practically all others this fracture remains unsolved.—*J. H. Vastine.*

Platt, Harry. Some remarks on the giant cell tumor of bone. *Surg., Gynec. & Obst.*, Feb. 15, 1935, *60*, 318–329.

The average yearly quota of giant cell tumors of the long bones in the larger general hospitals of Great Britain is not more than one tumor per year per hospital (Stewart).

The following table gives the clinical differences between solitary bone cysts in children and giant cell tumor in adults.

	Solitary Bone Cyst	Giant Cell Tumor
Age	5–15 (under 20)	20–35 (over 20)
Sex	M>F	F>M
Site of election	Humerus—upper end	Femur—lower end
	Femur—trochanteric region	Tibia—upper end
	Tibia—upper end	Radius—lower end
Site of origin	Metaphyseal	Epiphyseal
Clinical course	Trauma—fracture	(Trauma)—pain—tumor
	Spontaneous healing	Invasion and destruction

There are three clinical types of giant cell tumors:

1. The *indolent* tumor grows slowly and is not invasive. It is characterized by thick bony walls and coarse trabeculations roentgenologically and considerable fibrous tissue microscopically. It is rarely seen after age of thirty-five.

2. The active, rapidly growing tumor is invasive and destructive. Roentgenologically a large tumor of recent development is found, the bony shell of which is thin and attenuated and perforated at one or more points. Microscopically there is a profusion of giant cells, embedded in a background of actively growing cells, both of the round and spindle type. It is usually seen in young adults. Platt describes it as a malicious although not a malignant neoplasm.

3. Malignant giant cell tumors are rare but do occur. Whether this is a superimposed malignancy on a benign tumor (Geschickter and Copeland) or a primary malignancy from the beginning (Stewart) is an unsettled question. Malignant giant cell tumors are of long duration, first appearing as a typical benign lesion around the age of thirty. King believes that the loss of the outline of the bony shell, irregular trabeculation and shadow of tumor material in the soft parts indicate malignancy. Platt agrees with Bloodgood that perforation of the bony shell is not necessarily a sign of malignancy.

Treatment of Giant Cell Tumors

1. Curettage. Simmons reported cures by curettage alone as 62 per cent, and by curettage plus postoperative roentgen therapy as 72 per cent. The author recommends curettage with postoperative roentgen therapy except in certain sites unfavorable for operation, as the ilium, spine, etc., in which cases irradiation alone is employed.

2. Resection may be employed in lesions of the upper extremity except in the lower end of the radius, and occasionally in lesions of the fibula in the lower extremity.

3. Amputation is advised in tumors which have recurred following curettage or have resisted irradiation and in large tumors in middle aged patients in which there is suspected malignancy or in which the deformity is great.—*J. H. Vastine.*

Giraudi, Gioffredo. Studio radiologico sull' osso Sacro. (Roentgen study of the sacral bone.) *Radiol. med.*, 1936, *23*, 147–164.

The author studied the anatomy and roentgen anatomy of the sacral bone in detail and gives roentgenograms of the images seen in

different projections. The details can best be studied in connection with these roentgenograms. He calls attention particularly to a few points, however: (1) the usefulness of the caudocranial projection in studying the base of the sacrum. This projection with the so-called planimetric and stratigraphic methods can be used on the living subject; (2) the interrelations between the roentgen picture of the terminal line of the pelvis and the surfaces of the sacroiliac joint; (3) the pictures of the sacral tuberosity and the roots of the arches; (4) the anatomical arrangement of the 1st, 2nd and 3rd sacral nerves which he thinks is a direct downward, forward and outward continuation of the intervertebral foramen; the posterior foramen not infrequently opens directly on the wall of the canal of the anterior branch but sometimes it opens indirectly through an accessory canal; (5) the wing-shaped images seen when the roentgen rays project the image of the anterior sacral foramen further caudad than the corresponding posterior foramen and cut the external wall of the duct which unites the two foramina tangentially.—*Audrey G. Morgan.*

Hermodsson, I. Zur Atiologie der Köhlerschen Krankheit des os naviculare tarsi. (Etiology of Köhler's disease of the navicular bone of the tarsus.) *Acta radiol.*, 1936, *17*, 68–73.

A child three years of age fell from a ladder and could not stand on her left leg; she complained of great pain in the leg. She had been normal previously and there was no family history of any importance. The symptoms were those of a fracture of the lower part of the tibia. Roentgen examination did not show fracture. The navicular bone was visible on the roentgenogram and did not show any pathological changes. A splint was put on and the child sent home. She complained of pain in the foot which became swollen and she did not walk. In the course of four and a half months the typical roentgen picture of Köhler's disease developed. It showed the usual benign course, and roentgen examination eighteen months later showed the bone normal. Clinical recovery was complete. The author thinks there is no doubt that the cause of the Köhler's disease in this case was the trauma and not a disturbance of development.—*Audrey G. Morgan.*

Overgaard, Kristian. Ein Fall von osteosklerotischer Anamie. (A case of osteosclerotic anemia.) *Acta radiol.*, 1936, *17*, 51–67.

A case is described in a woman, aged forty-one, who about six months before her admission to the hospital began to suffer from palpitation of the heart, buzzing in the ears and severe anemia. The details of the blood findings at different stages of the disease are given. The anemia did not correspond to any of the classical types. Not only were the hemoglobin and red cells very much decreased but there were intense pathological changes in the white cells. In addition to leukopenia there were large numbers of immature cells in the blood and the spleen was considerably enlarged. On this account roentgen treatment was given and the size of the spleen decreased under this treatment, which however did not materially affect the disease otherwise. The anemia resisted all the ordinary treatments such as liver, iron and arsenic but there was some improvement in the subjective symptoms under long-continued rest in bed and tonic treatment including carbon arc baths and several blood transfusions.

In connection with a roentgen examination of the chest it was found that the ribs gave unusually dense shadows; an examination of the whole skeleton was therefore made and sclerosis of practically all of the bones of the skeleton was found. Very few of these cases of osteosclerotic anemia have been described and the anemias accompanying them have not been very definitely classified. The form of the bones was not changed and the sclerosis was practically universal, which are differentiating points from osteoblastic carcinosis.—*Audrey G. Morgan.*

Cossu, Didaco. Osso soprannumerario del tarso o scafoide bipartito? (Supernumerary bone of the ankle or bipartite scaphoid?) *Radiol. med.*, May, 1936, *23*, 361–366.

An individual thirty-five years of age had had an injury of the metatarsal region of the right foot ten years ago. Since then he had had pain in the tarsal region. Palpation caused pain along the anterior and median borders of the scaphoid. Roentgen examination of the right foot showed a little ovoid bone on the anterior slope of the scaphoid at the articulation between the scaphoid and cuneiform. It was distinctly separated from the scaphoid by a transparent line. If it had been caused by the old fracture there would have been no such clear

line as the injury was so old that it would have been filled in by this time with bone tissue. The scaphoid at the place where this bone fitted into it showed a line of increased density. The roentgenogram of the left foot showed at the same site some irregularity of outline from slight defects in the bone.

The author concludes that this was a supnumerary bone due to ossification from a supernumerary center of ossification in the scaphoid. It failed to be united to the rest of the bone because of a dystrophic process which was indicated by the changes in the bone of the left foot at the same site. It is important in medicolegal cases to differentiate between such supernumerary bones and fractures and this can best be done by comparing the roentgenograms of the two feet.—*Audrey G. Morgan.*

BLOOD AND LYMPH SYSTEM

Leddy, Eugene T., and Desjardins, Arthur U. Metastasis of carcinoma of the breast to the supraclavicular lymph nodes. *Am. J. Cancer*, Nov., 1935, *25*, 611–613.

The occurrence of supraclavicular metastasis in patients with carcinoma of the breast was considered by the authors as a precursor of metastasis to the liver and lungs rather than the osseous system. In a group of 644 patients who were referred to the Section on Therapeutic Radiology at the Mayo Clinic, metastasis to the supraclavicular lymph nodes was diagnosed 358 times. In 126 of the 358 cases, the grade of the malignancy was determined by Dr. A. C. Broders. Five of the group were grade 2, 33 grade 3, and 88 grade 4. They found that this metastatic involvement usually occurred in the first three years after the original operation and that the larger majority of the primary tumors were situated in the upper quadrants of the breast.—*E. E. Downs.*

Geschickter, Charles F., and Keasbey, Louisa E. Tumors of blood vessels. *Am. J. Cancer*, March, 1935, *23*, 568–591.

Tumors of the blood vessels are perhaps as common as any form of neoplasm occurring in the human body. However, practically all of these tumors are benign and most of them are unnoticed during life. Of a series of 570 of these lesions, almost 435 occurred in the subcutaneous or submucous regions, and of these, more than 200 were superficially located on the face, scalp and oral cavity, and 164 on the surface of the body or extremities. Of the deeper seated lesions, 109 were found in the liver, 16 on the valves of the heart, and 10 in the peritoneal or retroperitoneal structures of the kidney, spleen, intestine or mesentery. These figures suggest to the authors that hemangiomas are likely to develop either from the central mesenchymal network or from the peripheral capillary growth zones.

The benign tumors might be grouped as either capillary or cavernous hemangiomas. The cavernous lesions are to be distinguished by their deep color (regardless of whether they be of arterial or venous origin), and their spongy collapsible makeup. These lesions are most frequently found in the liver; they are usually solitary, varying in size from 0.5 to 5.0 cm. in diameter and located near the surface. Most of them are discovered only by post-mortem examination, though in two of the group mentioned above the masses were palpable and surgical explorations had been performed. Superficially, cavernous lesions were most frequently found about the lips or tongue. In some instances, where coagulation had occurred, they appeared as hard nodular tumors. About two-thirds of the superficial lesions were of the capillary type. These included the telangiectatic dilatations (port-wine stains) and gradations from such to definitely raised and almost solid vascular masses. In some instances it was difficult to distinguish between capillary versus cavernous structure but where the color was bright red and the surface of the tumor conspicuously flat the capillary structure was found to prevail. Occasionally, infection or trauma had stimulated growth or ulceration and hemorrhage. Such lesions have oftentimes been called "hemangioma hypertrophicum," "hemangio-endothelioma" or "angioblastoma." Microscopically they may appear sarcomatous. With marked hypertrophy there may result anastomoses or even the production of arteriovenous aneurysms, with resultant alterations in growth of the involved regions.

The skeleton may show either the capillary or cavernous types of lesions. Multilocular areas of rarefaction are produced. In the long bones, these may simulate benign bone cysts. Occasionally, their location is subcortical so that they present a thin webbed expansion of bone.

The cavernous type of lesions predominate in the muscles. Very slight trauma to them

may result in marked swelling, pain, tenderness and impairment of function. The size of the swelling may change with change in position of the part and it is usually characterized by its softness and compressibility. The diagnosis might be substantiated by the aspiration of bright red blood or the roentgenographic outline of the tumor and the visualization of phleboliths.

Quoting from Dandy's series of some 600 tumors of the brain, about 5 per cent were vascular lesions. The clinical manifestations varied depending upon the location of the lesions but in most cases there was record of prolonged, periodic symptomatology. Neurovascular lesions may occur in the retina (where they are sometimes called "angioblastomata" or "von Hippel's disease").

Other tissues in the body may be involved with vascular lesions as implied by such terms as: "fibro-angioma," "angio-lipoma," "lympho-angio-cavernoma," "angiochondroma," "angiomyoma," etc. The so-called "glomic" tumors should also be mentioned—and "angio-myoneuroma"—showing arborization of arterioles, apparently connecting with neuromuscular elements. The arterioles show a lack of an internal elastic lamina and the nerve fibers are characteristically non-medullated. Between these elements there might be seen large ganglion cells. These lesions are usually located in the extremities, particularly in the hands and when present at the tips of the fingers they may be mistaken for felons, both clinically and roentgenographically.

Angiomas may alter the picture of either squamous cell or basal cell lesions. When vascular changes predominate in such lesions they produce painless enlargements of tumor mass, which in the course of six weeks to several years may reach dimensions of 0.5 to 11.0 cm. in diameter. These lesions are usually well encapsulated.

Formerly, there was frequent mention of malignant "endotheliomas," "hemangio-endotheliomas," "peritheliomas," "cylindromas" or "perithelial angiosarcomas." Many of these have been reclassified as "metastatic lesions of the thyroid or kidney, or as secondary deposits from non-pigmented melanomas." Some of the so-called "angio-endotheliomas" are now recognized as "adenocystic basal cell cancers," or as "aberrant benign mixed tumors of salivary type or as glomic tumors." With such classification, there are left three outstanding types of malignant vascular tumors: "metastasizing hemangiomas," "primary angiosarcoma of the liver" (found in infants) and "Kaposi's hemorrhagic sarcoma of the skin." All of these are very rare.—*A. A. de Lorimier.*

Brovelli, Mario, and Dolfini, Enrico. Le linfografia. (Lymphography.) *Radiol. med.*, May, 1936, *23*, 293–331.

The authors review the literature on the subject and describe the technique of their own experiments in the lower vertebrates and mammals. They used colloidal dioxide of thorium as a contrast medium. In certain of the lower vertebrates practically the whole of the lymphatic system was rendered visible. In certain mammals, including guinea pigs, rabbits and dogs, it was possible by injecting the thorium into the subcutaneous tissue of the limbs, into the tongue and into the nasal septum to obtain roentgenograms of the lymphatic vessels and glands of these regions. Injection directly into the popliteal glands opacified the efferent lymphatic tracts up to the thoracic duct; injection into the liver opacified certain retrosternal tracts; into the testicle the lymphatic network of this organ and the efferent lymphatic vessels; into the epididymis the spermatic tracts.

The injection of colloidal thorium did not produce true inflammation, except for the chronic periadenitis seen in the retropharyngeal glands of the dog, which is not definitely known to have been caused by the thorium. The predominant histological change, which was progressive, was an intense histiocytic reaction, which was often accompanied by retrogression or even complete disappearance of the lymphoid tissue of the glands. Serious changes were caused by direct injection into the lymph nodes which became blocked with thorium. In all probability, a collateral circulation was established which prevented serious lymph stasis. The vessels may become blocked with masses of thorium mixed with lymph clots.

It was not possible by this method to study the velocity of the lymph current. The permeability of the vessels could be studied and the phagocytic capacity of the glands.

The experiments are illustrated by many roentgenograms and microphotographs and a bibliography of the subject is given.—*Audrey G. Morgan.*

GENERAL

Cottenot, P., and Sluys, F. La téléroentgenthérapie totale. (Total teleroentgen therapy.) *J. de radiol. et d'électrol.*, 1935, *19*, 347–359.

This is a report presented at the Second Congress of Electroradiologists of the French Language in Brussels, 1935. It deals in extenso with the present status of total teleroentgen therapy, the subject being divided into the following sections: History, physical basis, technique, biological action, therapeutic indications, results and inconveniences.

As concerns the physical basis, two problems are considered in greater detail: (1) the irradiation of the entire surface of the body and (2) the homogenization of the depth dose. It is known that the irradiation of a flat surface perpendicular to the normal ray is practically uniform within a circle, the center of which is the point of intersection of the normal ray and the diameter the half of the focal distance. This indicates that to irradiate the entire body of an individual of 1 meter 75 cm. height, a focal distance of 3 meters 50 cm. is necessary. If the subject to be irradiated doubles himself up, a focal distance of 2 meters may be sufficient. To obtain homogenization of the depth dose the irradiation is made alternately on the anterior and posterior aspect of the body. A study was made of the factors controlling the depth dose, such as focal distance, voltage, and filtration and the results obtained are included in the following table:

Tension	Filter	Transmitted Dose at 16 cm. for Focal Distance of 2 m.	Transmitted Dose at 16 cm. for Focal Distance of 3 m. 34 cm.
200 kv.	1 mm. Cu	37%	40%
	2 mm. Cu	40%	41%
290 kv.	1 mm. Cu	39%	42%
	2 mm. Cu	41%	43%

In accordance with the above physical data the technique is carried out either with a distance of 3 meters 50 cm., 300 kv. and 1 mm. Cu, or with a distance of 2 meters, 200 to 300 kv. and 1 mm. or 2 mm. Cu. In both of these instances a dose which corresponds to about 10 r as measured on the surface of the patient is given two or three times weekly, the repetition and spacing depending on the blood formula. As a third method, one may include the procedure (of Heublein) at the Memorial Hospital where treatment is given from a distance of 3 meters 50 cm., with two tubes, the patients being placed daily for several hours in a veritable bath of the roentgen rays.

As concerns the indications, the opinion is expressed that teleroentgen therapy is the method of choice in the myeloid and lymphoid leukemias and in Vaquez's disease. It also forms an important adjuvant in the various forms of Hodgkin's disease either as a treatment of sustainment or primary attack. The method also has value in certain generalized dermatoses. In the lymphocytomas and seminomas which are known to represent very highly radiosensitive processes, the value of the method is as yet inconclusive.

The inconveniences consist chiefly in radiation sickness and blood damage. In connection with this latter it is emphasized that very careful hematologic control is indispensable to prevent too much destruction of the platelets and leukocytes during the course of the more intensive irradiation.

A bibliography of 28 articles is appended.—*T. Leucutia.*

Belot, J. La téléradiothérapie totale. Sa valeur thérapeutique. (Total teleroentgen therapy; its therapeutic value.) *J. de radiol. et d'électrol.*, March, 1936, *20*, 167–170.

The author already in 1904 demonstrated that it is possible to irradiate the entire surface of the body. In cases of generalized dermatoses this procedure was more or less realized when irradiation of the entire body was undertaken during a period of four to five days, the body being divided into various sectors. The simultaneous irradiation of the entire body through one single field, however, was undertaken only since 1932. For this purpose the author has installed two units, one operating at a distance of 3 meters 50 cm. with 200 kv. and various filters, and the other at a distance of 2 meters 64 cm. with 300 kv. (pulsating), and various filters. The method was tried in generalized osseous metastases from cancer, lymphogranulomatosis, highly radiosensitive sarcomas, seminomas, lymphocytomas, polyglobulia and the two forms of leukemia. In the generalized dermatoses the author continues to use the

total irradiation through three anterior and three posterior sectors at a distance of 1 meter 50 cm.

The author does not share at all the opinion of the reporting committee concerning the indications of total teleroentgen therapy. Thus he believes: that the procedure is entirely inefficacious in metastatic cancer; that in lymphogranulomatosis it may be used only as a method of sustainment after the manifest lesions have been successfully treated by the usual accepted procedures; that in the very radiosensitive sarcomas, seminomas and lymphocytomas the doses necessary for the destruction of the tumor are considerably larger than can be safely administered with total roentgen therapy and that even in the leukemias total teleroentgen therapy may be used only as a method of sustainment and primarily only in those cases in which the leukemia manifests itself without localization to the spleen or lymph nodes. In all these instances the irradiation is carried out with a cycle of two to three seances of 25 r per week. Of course during the entire course of irradiation a very careful checking of the blood formula is required.

The final conclusion is reached that total teleroentgen therapy is of value only in a very limited number of affections.—*T. Leucutia.*

Delherm and Stuhl. Sur les accidents et quelques indications de la téléroentgenthérapie totale. (On the accidents and some indications of total teleroentgen therapy.) *J. de radiol. et d'électrol.*, March, 1936, *20*, 170–172.

In agreement with what was said in the former articles, the authors stress the risks which total teleroentgen therapy entails on the hematopoietic system. Furthermore, they describe a case of leukemia terminating fatally in aplastic anemia which they attribute to the very extensive irradiation.

Because of the great danger the authors prefer to use total teleroentgen therapy merely as an agent of excitation of the bone marrow in cases of myelogenous, lymphoid or monocytic leukemia. By systematically irradiating the epiphyses one may effectively fight against the deglobulization which usually occurs in the advanced stages of the leukemias. One of the authors (Stuhl) had the opportunity to observe 30 cases of lymphogranulomatosis treated by his master, Dr. Mallet, with a benefit which was as great as by any of the old classical methods, but in a series of about 10 cases treated by himself the results were not as satisfactory. During the past few years the authors treated also 3 cases of asthma, one with healing, the second with amelioration and the third with no effect.

These rather contradictory results do not permit any final conclusions on the value of the method, but it seems that the study is worth further consideration.—*T. Leucutia.*

Ducuing, Marquès P., and Milesky. L'action de la roentgenthérapie totale sur quelques constantes biologiques. (The action of total roentgen therapy on certain biological constants.) *J. de radiol. et d'électrol.*, March, 1936, *20*, 177–181.

This article deals with experiments on 3 dogs which were irradiated totally with penetrating roentgen rays (depth dose of 10 cm., 56 per cent), daily doses of 25 to 100 r being administered until a full dose of from 950 to 1,500 r was reached. The following conclusions were drawn: (1) Total irradiation has not modified in dogs to an important degree the glycemia, cholesterinemia, blood urea and total nonprotein nitrogen. (2) It has led to a very intense leukopenia with practically complete disappearance of the white cells after having equalized the polymorphonuclears and lymphocytes. (3) The number of platelets and the level of hemoglobin have undergone a notable decrease. The reticulocytes showed a very marked decrease. (4) The 3 dogs irradiated presented a typical hemogenic syndrome characterized by progressive destruction of the platelets, very marked increase of bleeding time, no change of coagulation time, irretractility of the clot and clinically by multiple hemorrhages.—*T. Leucutia.*

Morelle, J., and Solé, H. L'examen radiologique dans la pathologie des glandes endocrines. (The roentgen examination in pathology of the endocrine glands.) *J. de radiol. et d'électrol.*, July, 1935, *19*, 360–400.

This is a comprehensive report as presented to the Second Congress of Electroradiologists of the French Language in Brussels, 1935. It deals with the roentgen signs resulting from alterations of the structure or function of the endocrine glands with the exception of hereditary and familial manifestations. The syn-

dromes, which are of pluriglandular origin, and the physiologic as well as the clinical interpretation of which is still somewhat confused, are likewise omitted. In presenting the various chapters only the morphologic roentgen signs are considered, the purely functional modifications being of uncertain and inconsistent value. The morphologic signs are divided into local, due to modifications of the glands proper, neighboring, due to alterations of the surrounding structures, and finally, distant, due to the effect on the entire organism.

I. Hypophysis. (*a*) Modifications of the gland. Normally the hypophysis has no roentgen sign. Occasionally one may encounter a calcareous impregnation or granular concretion in the region of the gland, however, without any diagnostic significance. (*b*) Modifications of the neighboring organs. Since the hypophysis is lodged in the sella turcica the changes observed in connection with this are of great importance. They may be classified according to variation in (1) dimension, (2) form and (3) osseous contour of the sella turcica. All these are discussed in great detail and the modifications characteristic for a pituitary tumor considered. (*c*) Diagnosis of sellar modifications of nonglandular origin. For the purpose of differential diagnosis the authors include in this section all those modifications of the sella which are due to lesions other than the pituitary gland proper, such as (1) metastatic lesions; (2) craniopharyngiomas; (3) juxtasellar tumors; (4) distant tumors; (5) Schüller-Christian's syndrome, (6) Marfan's syndrome; (7) Babinski-Froehlich's syndrome, and (8) Laurence Biedl's syndrome. (*d*) Distant modifications of hypophyseal origin. (1) Hyperfunction (*a*) of the eosinophile cells. These changes are characterized as gigantism and acromegaly. The first gives no characteristic roentgen appearance except that all the bones are uniformly enlarged without constant alteration or disproportion. In the second, one makes a distinction between the changes of the cranium and the skeleton. The cranium, as a rule, appears voluminous, thickened with an excessive development of the sites of the muscular insertions, enlargement of the pneumatic cavities and inconstant prognathism. The sella turcica may or may not be enlarged. The bones of the skeleton present a massive aspect with exaggeration of the crests of muscular insertions, osteophytes, enlargement of the epiphyses of the long bones, deformity and thickening of the phalanges and more or less pronounced decalcification of the entire skeleton, etc. (*b*) Of the basophile cells. This group includes chiefly the basophile adenoma which is also called Cushing's syndrome. The authors collected 16 cases from the literature dealing with such a lesion and on the basis of a study of the skeletal changes they make the statement that the osseous alterations in basophile adenoma of the pituitary gland are nearly constant, justifying the adjective of "osteoporotic" which the Germans have adopted for the characterization of this affection and which distinguishes the condition from the Babinski-Froehlich syndrome. The sella turcica presents only insignificant modifications which are out of proportion to the osteoporosis. (2) Hypofunction. (*a*) Nanism and infantilism, the skeletal changes of both being well known. (*b*) Simmonds' disease. This latter, which is also called the cachexia of Simmonds has as chief clinical characteristics: amenorrhea or impotence, loss of pubic and axillary hair, general fatigue, psychic apathy and progressive cachexia. The roentgen signs in some instances may be nil, in others they may represent changes of the pituitary region as observed in craniopharyngiomas, pituitary adenomas, syphilis or tuberculosis involving the sella, etc., which may be the provoking cause of the disease. It is therefore recommended that an examination of the sella turcica should be made routinely in all instances of Simmonds' disease to attempt to clarify the cause.

II. Epiphysis (pineal gland). The endocrine function of the pineal gland still remains obscure except for the fact that it is associated with constitutional disorders known under the name of precocious puberty. There are no roentgen signs in connection with changes of this endocrine gland. The presence of calcifications within the gland which occur in from 40 to 60 per cent of the cases sometimes becomes a valuable sign in the diagnosis of brain tumors by showing a displacement from the midline due to the pressure of the tumor.

III. Thyroid gland. (*a*) Modification of the gland. The roentgen examination of the neck with soft tissue exposure permits the estimation of the size of the gland, the presence of intraparenchymatous calcium deposits, and especially the retrosternal extension. (*b*) Modifications of the neighboring organs. These refer chiefly to the deviations and deformity of the trachea and distortion of the vascular shadows;

occasionally there being also a pressure effect on the esophagus. (*c*) Distant modifications. (1) Hyperthyroidism. A review of the literature reveals the fact that an osseous atrophy of the entire skeleton with increase of the calcium excretion may be observed in certain cases of hyperthyroidism chiefly of the Basedow type. This thyreogenic osteoporosis manifests itself in an increased general translucency of the skeleton. In addition, one may encounter an increase in length of the skeleton, a premature presence of the ossification and an acceleration of the epiphyseal union. (2) Hypothyroidism. The condition due to a hypofunction of the thyroid gland is characterized as myxedema which may be either of congenital, endemic acquired or postoperative origin. In very advanced cases of myxedema very extensive osseous changes, especially of the base of the skull, may occur, consisting in thickening and marked deformity of the osseous structures. In this respect the specimen and roentgenogram of a very illustrative case are included. (3) Thyroid cancer. Metastases to the skeleton forms one of the most common occurrences in thyroid carcinoma.

IV. Parathyroid glands. In connection with this gland only the distant modifications are of diagnostic importance. (1) Hyperparathyroidism. The roentgen signs refer chiefly to the osseous system and urinary apparatus and according to the predominance of one or the other one may establish the following classification: (*a*) Classical form (von Recklinghausen's disease), consisting chiefly of generalized decalcification, deformity, cysts, tumors, spontaneous fractures. (*b*) Osteoporotic form, characterized by general decalcification but without cysts or tumor formation. (*c*) Hyperparathyroidism complicated or coincident with Paget's disease. (*d*) Hyperparathyroidism associated with nephrolithiasis. This form may be complicated by secondary pyelonephritis and may occur without any evidence of osseous changes. (*e*) Hyperparathyroidism with renal insufficiency, the symptomatology of which resembles that of vascular nephritis. The authors were able to collect a total of 105 cases of verified parathyroid tumors. On the basis of this they have established the most characteristic roentgen signs which are all described in detail in the text. (2) Hypoparathyroidism. In the essential or postoperative hypoparathyroidism one may observe a disease of mineral metabolism characterized by a decreased calcium excretion. The exaggerated mineral retention, however, is not sufficient to produce roentgen signs. Certain authors have described osteomalacic manifestations and epiphyseal disorders' similar to late rickets in tetany, but it is possible that these changes represent only accidental occurrences.

V. Thymus. The importance of roentgen examination as well as roentgen therapy in thymic disorders, especially in infants, is now well established. The endocrine function of the thymic gland is as yet insufficiently known.

VI. Suprarenal glands. A. Modifications of the gland. The modifications leading to a disturbed function of the suprarenal glands may be due to tumors or inflammatory lesions. To American authors goes the credit of having demonstrated the frequency of suprarenal calcifications in case of Addison's disease which might be of three types: (*a*) massive calcification of the entire gland; (*b*) slightly calcified multiple zones extending throughout the gland, and (*c*) a homogeneous increase in the density of the gland. B. Modifications of the neighboring structures. Tumors of the adrenal glands may produce a pressure effect on the diaphragm, kidneys and if localized on the right side, on the duodenum. These effects may be demonstrated roentgenologically. C. Distant modifications. The endocrine action of the suprarenals does not lead to osseous changes. Certain authors described osteoporosis and spontaneous fractures but it is probable that these changes are the result of Cushing's syndrome rather than a disturbed function of the adrenal glands proper. One may call attention to a tumor (neuroblastoma or sympathoma) which originates from embryonal rests of the adrenal glands and which leads to multiple metastases of the abdominal viscera and of the flat bones, especially at the level of the cranium and orbit and in which the motheaten roentgen appearance of the skull may be of diagnostic value even before the clinical manifestations of the primary tumor.

VII. Genital glands. The changes as the result of disturbances in the endocrine function of either the ovary or testicle are as a rule undetectable roentgenologically.

A bibliography of nearly 350 articles is appended.—*T. Leucutia.*